PROCEEDINGS

OF THE

YORKSHIRE

GEOLOGICAL & POLYTECHNIC

SOCIETY.

NEW SERIES—VOLUME VII.

1878–1881.

EDITED BY JAMES W. DAVIS, F.S.A., F.L.S., F.G.S.

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ADDRESS BY LORD HOUGHTON, D.C.L., F.R.S., &c., &c., VICE-PRESIDENT.

The Chairman said:—It occurred to me sometimes, but not often, in my parliamentary life, to find a man so full of his knowledge that he was confused and almost unable to express it; and it also occurred to me sometimes to find a man with very little knowledge able to use it so adroitly as to make people believe that he knew a great deal. But as I do not wish to place myself, or am unable to place myself, in one of these positions, and am unwilling to place myself in the other, the words I have to say will be very few, because of the main subjects of this society I know very little, and am here rather to learn than to teach. In my younger days the science of geology was in its commencement, and I remember the sensation produced in all literary and scientific circles in Yorkshire by the appearance of the work of our excellent countryman Mr. Phillips. It was almost a revelation of a new science to many ingenious and inquiring minds, and by all Yorkshiremen was regarded as the discovery of a mine of infinite

future interest by a man now gone from us, carrying with him the respect he had won. He may be considered as the founder of Yorkshire geology, and any means we have of continuing his operations and elucidating the facts of which he laid the foundation will, I am sure, be most grateful to all persons of intelligence in our important district. The geology of Yorkshire is so large and so various that there may be found in it sources of instruction for almost every geological system. It is different in that respect from many of the counties which lie contiguous to it, especially different from that great fen land which may be said to extend from Grimsby to Ely, and upon which a most interesting work has lately appeared which I would recommend to the study of all geologists. The time will come when some future geologist will collect together the scattered materials which you are now laying before the world, and produce a more complete geology of Yorkshire than any which has hitherto appeared. The study itself is acquiring far more remarkable interest than it could have done in its earlier commencement. The foundations of it have been taught in some of our best schools, and the direction of it was given to youths in many of our most important centres as a valuable source of information. We must all feel that this is a right and a natural thing, because there is no study which could be suggested to the minds of young people in which they would be better able to connect the material world in which they are immediately living with the processes of their own intelligence. I have always felt that besides any abstract advantage of knowledge itself there was a special interest and a special value in all those sciences which connect a man with the immediate circumstances in which God has placed him. And thus if you could induce all the young people who come within your influence after a very superficial instruction in the main facts—that is, in the grammar

of geology—to see how they could apply those facts to the immediate observation of the country in which they live, you would find, I think, that these elementary facts which are taught to them, even though superficial in themselves, yet give a sound foundation for future observation. In the interesting address given to you in 1877 by the Marquess of Ripon, he drew your attention very vividly and in very eloquent language to the effect of the observation of the great phenomena of nature upon the general intelligence of the mind of man. He has done that so well that I will not attempt to follow him in the same path; and I would merely add, in regard to that observation, that I am very thankful to see either in his words or in any others, a recognition of the fact that the extension of the knowledge of the observation of phenomena cannot do anything which may be considered injurious to the highest faculties of the mind. There were men in the early part of this century, and who have continued through a very considerable portion of this century, who had a kind of suspicion of science as being something antagonistic to the higher and more important qualities of the mind. People seemed to think that because men knew more they would either think less or feel less. That was a most erroneous opinion, and it has been completely answered by the facts of the world in which we live. Never has there been a time in our history in which so much interest has been taken in Science. At the same time, never has there been a time in which greater interest has been taken in all those developments of the imagination which are generally comprised in the name Art, nor in those deeper developments of mankind which are generally comprised in the word Religion. No doubt there will be certain minds which addict themselves specially to science, and which seem to take very little interest in what are considered still higher aspects of humanity; but it does not at all follow that be-

cause a man devotes himself to science he would be any the better for not knowing science at all. The condition of that man would be that he would be deprived of that one development of his nature, and not that he would be inclined to anything else. Therefore do not let anybody be persuaded that it is a disadvantage to young people to show a special interest in the observation of the world about them. I am sure that there is no better test of the intelligence of youth; and if I were to say what boy I would take for a man of business in my office of any kind—the boy who showed an active intelligence, and a desire for science, or the boy who seemed solely inclined to look after figures and book-keeping—I would say that the one whose observation was attracted to the phenomena of the external world would be more likely to rise in life by attention to his business and assiduity in his profession, than the other who has not shown any disposition of that kind. This being the case, I would ask you to pursue the object you have taken up, each of you in your own special locality. The science of geology is one which will go on advancing in a far greater proportion than it has yet done. How rapidly that science has already developed will, I think, be evident to every one of you who has studied for about twenty or thirty years. I do not know exactly the year, and I will not mention names, but I remember perfectly well one of the greatest lights of the geological world of his time coming to see my father at Fryston, and regretting that such was the peculiar condition of that district that there was no possibility of any coal measures being discovered in that part of the county, the discovery of the formation of coal measures under limestone being impossible. One word more I would recommend to the special attention of this society. It is that you would induce all your members to pay more attention if possible to their immediate district

even than to the general studies to which the society is applying itself. The last volume of your transactions shows that this has not been hitherto neglected, and although I see that one of your members went so far out of the West Riding as to give us the German Ocean as the subject of a communication, yet, nevertheless, I am glad to see that the greater part of your later contributions and those to which we shall direct attention to-day are of a local character. Do not for a moment be led to consider that these observations are of less importance because they are local. I am sure you will find that the leaders of science would say—Direct your attention to these local objects rather than attempt any generalisations, even though they may be of an original character. I do not say that you may not occasionally diversify your proceedings by generalisations; nevertheless, remember that the more provincial you are the better.

ON A NEW METHOD OF STUDYING THE OPTICAL CHARACTERS OF MINERALS.

BY H. C. SORBY, F.R.S., PRES.G.S., &c.

As is well known, the optical characters of minerals furnish us with a most valuable means for identifying the various species. The practical application of these phenomena has, however, been much restricted by the difficulty of obtaining crystals sufficiently large and transparent to be cut into appropriate sections, so that the properties of some of the commonest minerals were very imperfectly known. By the methods hitherto employed it was almost impossible to study the black or imperfectly transparent minerals constituting the chief part of rock masses, and in fact little could be learned unless the specimens were so large and perfect that the individual species could be identified by other means. What

we want is a method which will enable us to ascertain the approximate value of the principal optical constants, when we have at our disposal only detached, small, and imperfect crystals in their natural state, or those scattered about in thin sections of rocks, cut into plates which are inclined at every varying angle to the optic axes.

The method now to be described satisfies these requirements sufficiently well. Time would not permit me to give a full description of the apparatus, the manner of using it, and the conclusions to be drawn from the observed data. I must therefore avoid all unnecessary detail, and confine myself to such an outline as will serve to indicate the general character of the method. I may here say that I have received most valuable assistance from Prof. Stokes in the mathematical part of the subject.

When, many years ago, I first commenced to apply the microscope to the study of minerals, I was told by a well-known professor of mineralogy that it would never be possible to learn much by the use of that instrument. If we merely magnify a portion of a pure transparent crystal, we do, indeed, learn little or nothing; but if, instead of viewing the crystal itself, we look through it with a suitable magnifying power at some appropriate object, we can learn more facts of interest and importance than by any other single method whatever. The property possessed by the object-glass of collecting divergent rays to form an image gives rise to an entirely new class of phenomena, and converts the microscope into a most valuable apparatus for optical research. The object examined through the crystals is the image of a small circular hole, or of rectangular lines ruled on a piece of glass, formed at the focal point of a well-corrected achromatic condenser fixed below the stage, and so arranged that the image is placed either just below or just above the lower surface of the crystal. The divergent rays passing through it to the object-glass are

bent so that the focal length is, as it were, increased by an amount depending on the thickness of the crystal and its refractive power. In order to see the lines in focus, it is therefore necessary to move back the body of the microscope. If we know the thickness (T) and the amount of the displacement of the focal length (d), we can calculate the value of the index of refraction (μ) from the equation, $\mu = \frac{T}{T-d}$

These values are measured by means of a scale and vernier attached to the body of the microscope; and, with care, there ought to be no error greater than $\frac{1}{2000}$th of an inch. The thickness of the specimen (T) is determined by measuring the difference in the focal points for particles of dust on the surface of the supporting glass and on the upper surface of the mineral. In a similar manner the value of d is determined by the difference in the focal length for the lines of the grating seen through the supporting glass with or without the specimen under examination. From the value of the index thus determined a small amount must be deducted, depending upon the aperture and correction of the object-glass, and, when great accuracy is desired, several precautions must be taken to avoid a number of possible small errors, which it would be tedious to explain in detail.

In the equation, $\mu = \frac{T}{T-d}$, it is assumed that the substance possesses no double refraction, as in the case of glass or crystals belonging to the regular system. When viewed through such a substance, only one simple and undistorted image of the circular hole can be seen, and both sets of lines are in focus at the same adjustment, no matter what may be their azimuth to the axes of the crystal. We obtain by measurements and calculation one single index of refraction, but this may vary so much in different minerals as to clearly point out what they are. Thus, for example, it varies from

1·43 in fluor to 2·34 in blende. If, however, the crystal possesses strong double refraction, the phenomena are far more complex, and vary according to the direction in which the section is cut, its azimuth to the lines of the grating, and also according as it has one or two optic axes.

If we look through a parallel plate of a uniaxial crystal with powerful double refraction, like calcite, cut perpendicular to the principal axis, we see two undistorted images of the circular hole, directly superimposed, one over the other, but separated vertically by a wide interval. This doubling of the image is due to the collection by the object-glass of divergent light, since, for strictly parallel rays passing in the same general direction, there is no double refraction whatever. Both systems of perpendicular lines are seen in focus at the same time in each of the images, one of which is due to the ordinary, and the other to the extraordinary, ray. By observing these focal points we obtain two indices of refraction, one being the true index of the ordinary ray (μ), and the other not that of the extraordinary ray (μ'), but a very low apparent index, equal to $\frac{\mu'^2}{\mu}$.

When the section is cut in other directions the images differ very much from one another. That due to the ordinary ray has invariably the same properties. The circular hole is not distorted, and both systems of line are in focus at the same time, so that we may call that image *unifocal.* The other image, due to the extraordinary ray, instead of thus maintaining a constant character, changes very greatly, the maximum of change being when the section is cut parallel to the principal axis of the crystal. There is no focal point whatever at which the circular hole is seen of its true size and shape, and the entire circumference is never all in focus at once. There are two special foci, widely separated, at which the circle is, as it were, drawn out into a long band, at one

focus parallel, and at the other perpendicular to the axis. If the section be strictly parallel to the axis the focal point of the ordinary image is nearly half-way between these two foci of the extraordinary ray, and coincides, in horizontal position with the point at which the two elongated bands intersect. There is thus no lateral displacement of the images. If, however, the section be not parallel to the axis they are displaced laterally, this character being a very delicate test of the accuracy with which the section has been made. In fact, in all cases, if the two opposite surfaces are parallel, the character and position of the images at once indicate the exact relation between the optic axes and the planes of the plate, whether they be natural or artificial.

On viewing the rectangular grating through a section cut more or less nearly parallel to the principal axis, no lines whatever can be seen by means of the extraordinary ray, unless one system is nearly parallel to the axis. At one focal point one system of lines is seen, and at the other focal point the other system, so that the image due to the extraordinary ray may be said to be *bifocal.* On rotating the grating, the lines are seen to become broader, then obscure, and finally invisible. Unlike the image due to the ordinary ray, the bifocal image has thus a special focal axis, and the lines can never be seen in sharp focus if they are not either parallel or perpendicular to this axis.

On the whole, then, we have three focal points, one for the ordinary, and two for the extraordinary ray; and by observing these we obtain three different indices of refraction, one being that of the ordinary ray μ; and, provided that the section is closely parallel to the axis, the index derived from the lines parallel to the axis in the extraordinary image is the true index (μ') of the extraordinary ray, whilst the third index is of the very abnormally high apparent value $\frac{\mu^2}{\mu'}$.

The characteristic peculiarity of crystals like aragonite, which have two optic axes, is that, when the section is so cut that the images are directly superimposed without lateral displacement, they give two bifocal images, and four apparent indices. When cut in particular directions one of these images may become unifocal, but then there is a more or less considerable lateral displacement of the two images. When the section is cut perpendicular to the line bisecting the acute angle between the optic axes, so as to give two very bifocal images, the images of the circular hole are crosses at two different foci, and not, as in the case of calcite, two circles. Biaxial crystals have three true indices of refraction (μ, μ', μ''), and, if the section be accurately cut in the plane of any two of the axes of elasticity, so that there is no lateral displacement of the images, the four apparent indices observed from the lines of the grating are as follows:—

	Polarised in one plane.	Polarised in the opposite plane.
From lines perpendicular to the plane of polarisation	μ	μ'
From lines parallel to the plane of polarisation...	$\frac{\mu''^2}{\mu}$	$\frac{\mu''^2}{\mu'}$

Calling these observed indices a, b, c, and d respectively, we thus have $\mu'' = \sqrt{a\,c}$ or $\sqrt{b\,d}$. It follows from this that we can determine the value of all three indices by very simple observations, made by employing a single section cut in the plane of any two of the three axes of elasticity. Absence of lateral displacement in the images at once shows us that the specimen in its natural state, or as artificially cut, is sufficiently parallel to one of these planes to be suitable for the determination of the indices; but even if it is not such as to

give all three indices absolutely true, one at least may be correct, and the others may be determined approximately. In any case the character and position of the images at once shows in what direction the section is cut, or the relation which any parallel planes of a natural crystal bear to the optic axes, though the phenomena are more complex than in the case of uniaxial minerals.

It would occupy far more time than can be allowed on the present occasion to describe in detail the curious and anomalous appearance due to dichroism or to the laminar structure of particular minerals which gives rise to complex internal reflections. My chief aim has been to call attention to the very valuable facts which may be learned by viewing a circular hole or rectangular grating with a microscope through a parallel plate of any crystalline mineral. The data thus obtained are so remarkably characteristic that they alone would amply suffice to identify a large proportion of natural minerals. In many cases all the necessary observations can easily be made with small crystals in their natural state, which alone is of course a very great gain for practical mineralogy. The chief value of the method is, however, that it enables us to identify portions of minerals of microscopic size in sections of rocks as thin, or even thinner than $\frac{1}{400}$th of an inch, with an amount of certainty which leaves little to be desired.

When examining specimens of such a size that their thickness must be measured by means of the scale attached to the body of the microscope, I find that an object-glass of about $\frac{2}{3}$ inch focal length, combined with a somewhat highly magnifying eye-piece, gives the best results. When, however, we come to study the minerals in moderately thin sections of rocks, it is impossible to measure the thickness and the displacement of the focus sufficiently accurately by means of the scale and vernier. The fine adjustment screw of the

microscope may then be employed along with a $\frac{2}{5}$ or $\frac{1}{5}$ object-glass, and, if properly constructed and used, the requisite measurements may be made to within $\frac{1}{20000}$th of an inch. We may thus approximately determine the indices in sections only $\frac{1}{1000}$ of an inch in thickness. It is, however, necessary to adopt a system which reduces the number of separate measurements and to a great extent eliminates several sources of error. Instead of attempting to measure the *absolute* thickness of any particular crystal, and the actual displacement of the focal length due to it, the *apparent* thickness of the mineral, *as seen through itself* (t), is measured by means of the rotation of the graduated circular head of the fine adjustment by focussing, first to the top and then to the bottom, of some appropriate specimen. In each particular substance this apparent thickness is equal to the true thickness divided by the index of refraction. The thin glass cover is made somewhat larger than the section, so as to project beyond it, and inclose a layer of the hard and brittle balsam used to fasten down the piece of rock. Selecting for observation a specimen as near as possible to this balsam, so as to avoid any error due to unequal thickness, the difference (d'), in the displacement of the focal length due to the mineral, and the balsam is ascertained by focussing through each the lines of the grating. This value is positive or negative, according as the index of the mineral is greater or less than that of the balsam. It then follows that $t \pm d'$ is the thickness, as seen through itself, of the amount of balsam of the same real thickness as that of the mineral: the effects of the balsam below and above it, and of the covering-glass, being thus entirely eliminated. If, then, the index of the balsam be m, we can easily calculate that of the mineral (μ) from the following equation:—

$$\mu = m\frac{t \pm d}{t}.$$

In the case of the hard and brittle balsam used to fasten down the specimen, the value of m is about 1·54; but, if there be any doubt about the true index, it can be ascertained by special measurements.

In a similar manner we may determine the index of some unknown mineral by comparing it directly with some other mineral lying near to it, the true index of which is either well known or has been previously ascertained from special measurements. For this purpose quartz is often very suitable, since its index varies very little. One great advantage of this method is that specimens may be observed far away from the edge of the section, provided of course that the minerals compared are so close together as to prevent any error due to unequal thickness in different parts.

It must be borne in mind that, when any mineral has a very powerful double refraction, its apparent thickness, as seen through itself, varies according to the particular ray used for illumination and the direction of the objects chosen to determine the focal distances of the lower surface. There is, however, generally no difficulty in measuring with sufficient accuracy the mean apparent thickness, or that corresponding to some one image, and in calculating out the results accordingly.

In connection with this subject it may be well to call attention to a somewhat interesting fact. If we have, side by side, two substances of different refractive power, but of the same *absolute* thickness, their apparent thicknesses, *as seen through themselves*, vary directly as the velocity with which light moves in them. Indeed, strictly speaking, the determination of minerals in the manner now described depends entirely on an indirect measurement of the velocity with which light is propagated through them in different directions.

In order to illustrate the practical applications of this method, I will describe the results obtained in the case of a

section of dolerite from near Glasgow, which, on an average, is about $\frac{1}{400}$th of an inch thick.

I found that the index of a colourless transparent mineral, filling up cavities between the original minerals, was about 1·48 or 1·49. This exactly corresponds with that of analcime, with which its other optical characters agree.

Another colourless mineral, also filling cavities, was found to have the indices and other characters of calcite.

A third colourless mineral, evidently an original constituent, was seen to have a comparatively feeble double refraction, and its index was found to be 1·61. Its general appearance was like that of some felspar, but this index clearly proves that it cannot be any species which contains a considerable amount of alkali, which would greatly reduce the refractive power. The index of labrodorite was not previously known, but I find that it is 1·61, and therefore there can be little doubt that the mineral in the section is that species.

The section also contains a number of transparent reddish-brown crystals, their index of refraction being about 1·79. This and their other optical characters closely agree with those of the dark augite in the lava of Vesuvius.

In now concluding this short address, I cannot but feel that I have been obliged to omit all allusion to many points of considerable practical importance. I have not attempted to describe the subject in such a manner as would enable any one to at once practically apply the method in all sorts of cases. I gave a somewhat full account of one branch of the subject in my address at the meeting of the Mineralogical Society at Plymouth, and entered into the more purely microscopical aspect of the question in my late address at the anniversary meeting of the Royal Microscopical Society. I propose to communicate a detailed paper to the Royal Society as soon as a correct explanation can be discovered of certain small

but remarkable discrepancies between mathematical theory and observation. My chief object now is simply to point out what valuable facts may be learned respecting the nature of any mineral by looking through it with a microscope at a circular hole or rectangular grating. This is a totally different thing to magnifying the mineral itself, or to looking through the mineral at any distant object without a microscope. The success of the method depends entirely upon the optical conditions characteristic of a compound microscope. I have lately greatly improved the apparatus hitherto employed, but the examples already given will, I trust, serve to prove that even with the less perfect appliances, it was possible to identify in a very satisfactory manner many of the minerals met with in thin microscopical sections of rocks, and thus to determine their constitution with far more certainty than heretofore.

THE GEOLOGICAL HISTORY OF EAST YORKSHIRE.

BY THE REV. J. F. BLAKE, M.A., F.G.S.

The county of Yorkshire is broadly divided by the great plain of York into two very distinct districts; that to the west comprising the romantic scenery of the Pennine chain and its dependencies, while that to the east forms the feebler but not unimportant elevations of the moorlands and wolds. This eastern portion of the county is altogether of a later date in geological history than the western, and contrasts with it strongly in this, that while the latter is almost entirely composed of an extraordinary development of one formation, the former is made up of the collected fragments of many, which severally, as it were, enter an appearance in the district, but contribute very variously to its actual substance. In this feature, indeed, lies the chief interest of its history. It is no interminable mass of similar rocks, varied only by

the substitution of limestone for shale, or of sandstone for grit, but each valley yields new developments, and no cliff is long like its neighbour. Its varied formations have not been neglected by geologists, and the materials for its general history are sufficiently abundant.

The newer deposits on any area must of necessity take their character, to a greater or less degree, from the form of the ground produced by its earlier history. Where an axis of elevation is known to exist, we shall expect it to act as a barrier between the areas on either side of it, so that the deposits formed in them shall be different both in character and position; or when such a difference is actually perceived, and an axis of elevation exists in a neighbouring district, we may safely conclude the extension of that axis into the area in question. Thus the great fold which bounds the Yorkshire coal field on the north, and brings up the older rocks in the neighbourhood of Harrogate, would seem to have been continued to the east, and to have had its effect on all subsequent deposits. To the north of this east and west line is found a large development of newer rocks, whose character is peculiar to the district; while to the south are the last remnants of another series of deposits, which here seem to find their northern limit, but which are extended southwards through Lincolnshire into the Home counties.

This restriction of areas is of necessity most marked in the older portions of the series—for the amount of deposited material, the various changes of elevation that the country undergoes in process of time, must tend to obliterate the distinction; and by the time the chalk was formed we shall not be surprised to find that it is recognisable no longer, or at least only so far as new axes of elevation seem always to have a tendency to follow the lines of old ones.

The truth of these premises will come out most clearly, and the conclusions derivable from them will be most

certainly established, by an account of the peculiarities which attach to the several formations in this district.

The great separating formation which lies between East and West Yorkshire, and spreads out in the wide intervening plain, is the Trias. The hypothesis of Prof. Ramsay—founded partly on the colour, and partly on the absence of marine remains—that this is a deposit in a great inland salt lake, is well known; and the general characters of the Trias are not different in Yorkshire from those elsewhere. If we accept this hypothesis, we must conclude that the boundary of this inland sea was some little distance north of the Tees, and that the effects of the elevation of the carboniferous rocks were not yet manifested in the separation of the East Yorkshire area; for the Keuper marls have a uniform development throughout.

The uppermost portion of the series differs in a remarkable manner from its development to the south. The great masses of black shales and limestones which form the massive of the Rhœtic Alps, and have there a thickness of more than 1,000 feet, have dwindled to 100 ft. before they reach our shores; and the further north we go the more feeble they become, till, from the neighbourhood of Gainsborough to the Humber, and throughout Yorkshire, they are almost unrecognisable; and the particular stratum which usually renders them so remarkable—that thin zone of phosphatic nodules, associated with innumerable bones, the reliques of some sudden catastrophe, known as the bone bed—is not to be traced. All this may have been caused by the gradual elevation of the base on which the Trias rested, and we may thus approximate to the date at which the Yorkshire area was separated from the southern.

That the two areas were ever absolutely cut off from each other, so that no community of fauna could exist, is of course negatived by the identity of successive zones of life through

the whole of the Liassic area of Great Britain; but the sediment came from different sources. In the North Yorkshire area, or, as we may call it, the Yorkshire basin, we miss the fine clays and the smooth intercalated limestones which, occurring so frequently at the base in other districts, have obtained for the formation its name; and in their place we find rubbly, coarse, calcareous, clayey beds, with oyster and cardinia bands. These are succeeded by clays and thin ironstones; giving place, in their turn, to sandstones, with a new series of oyster bands; and these, again, were covered with the calcareous rocks which are now ironstones. Above these come the clays of the Upper Lias, to complete the deposits of that epoch. Almost all of these beds below the last show a remarkable thinning out as we go east or south from Redcar, to come to a minimum in the centre of the basin. These phenomena point to a local source for the sediment. Probably throughout the whole of England the Lias clays are derived from the denudation of the coal measures; and the local characteristics of the former may be more or less due to the neighbouring features of the latter, when not disturbed by the intermixing of streams from many sources and the spreading out their deposits over large areas. But in the case of the Yorkshire basin we seem able to trace this more exactly, and to see the beds of the Lias following in inverse order those of the carboniferous series.

The great upheaval which separated the Yorkshire from the Durham coal field must have left a vast anticlinal area of coal measures in a state peculiarly fitted to be acted on by denuding agencies; and thus from its *debris*, not carried far, and therefore not very fine, the earlier Liassic beds were formed—at first, it may be, contaminated by Permian limestone or other extraneous matter; till at last the rain and rivers, settling down to their main work of consuming the coal measures proper, were enabled to reproduce them in the

clays and ironstones of the upper part of the Lower Lias in such a manner as to deceive by their similarity the working but uninstructed miner of our day. The absence of bitumen in these clays may be accounted for by the probability of the interval between the two coal fields not being very productive. At last the coal measures were exhausted, and the millstone grit began to be attacked. There was less of this to wear away, so the results were smaller; but they were sandstones like the originals, and are seen in beds of that character in the Middle Lias. These once more gave place to the underlying rocks as a main source of deposit, and the Yoredales and Scar limestones yielded the increasingly calcareous rocks with which the Middle Lias terminated.

Although these are now ironstones, there cannot be much doubt as to their original nature, and that they have undergone subsequent change. Whence the iron came that took the place of calcareous matter may not be clear, though possibly the basalt which formed the wider extension of the whin-sill may have contributed some.

The great oysters of this period, and other associated fossils, indicate a shallowness of the water, owing to the rate of deposition being greater than that of the depression ; but at last a change came, the neighbouring land was depressed with the sea, a wider drainage area took in some of the coal measures once more, and gave us the shales of the Upper Lias, with their jet-forming bitumen derived from the richer beds of coal. This Upper Lias has a less thickness than the Lower, because it was derived from a smaller area of coal measures, and it more quickly filled the sea. Thus, by the time the millstone grit and lower beds again became the source of supply, the sea was so shallow that nothing but estuarine beds could be formed, into which the plants of the Oolitic period were carried. Thus, it is to local circumstances that the estuarine character of the Yorkshire Inferior Oolite is due.

It is known, however, that intercalated amidst these estuarine beds are three well-known marine bands; one, indeed, below them all, and therefore easily accounted for by the estuarine conditions not having set in. In addition to these, a fourth, well characterised, has recently been discovered by Mr. Borrow, of the Geological Survey, in the northern area. Nothing is more difficult, however, than to truly correlate these with all the intercalated limestones of the same series in the Howardian Hills. Thus we incidentally have proof of their local character. We may therefore explain them by minor changes within the district, some of which were favourable to the development of marine life, which left its relics as limestone rock. In some places, doubtless, coral reefs of small size were able to establish themselves. But the total result evidently was that the sea became so shallow that none of the rich material which elsewhere made the great limestones of the Great Oolite ever reached the district, and a period of slow deposition dragged on its weary length till fresh changes were brought about.

Not one of these observations applies to the small patch of Oolitic and Upper Liassic rocks to the south of Market Weighton. There the Middle Lias is capped by beds of a more southern character, the Upper Lias has no jet, and the small patchy representatives of the Lower Oolites are as much or more marine than estuarine. Here then we have the farthest outskirt of a large area of deposition, showing in Lincolnshire its own peculiar features, but scarcely exhibiting them in this little corner of Yorkshire. These beds, however, are of great use as showing how isolated is the true Yorkshire basin, and how truly local are its deposits.

This brings us to the close of the first chapter of the history. After the cornbrash was formed, which may be regarded as merely another local limestone (there is none in South Yorkshire), to be accounted for as before, a new series of

events commenced, which had but little relation to those that went before.

The first change appeared in the direction whence the sediment was derived. No longer it came in a regular though slow manner from the west, but rapidly-increasing sandbanks were formed, now known as Kelloway rock. The largest followed to a certain extent the line of the most northerly deposits, from Scarborough to the Roulston Scar, while another series were deposited along a southerly line from near Malton to the Humber. After this the whole area slowly sank, and the line of separation between the true Yorkshire and Lincolnshire areas became nearly obliterated. The deepened water admitted of a clay deposit, derived possibly from a still further depression of the carboniferous area, bringing the coal measures once more beneath the action of the denuding forces. This, the Oxford clay, spread over the whole area, and united Yorkshire again to the south. It lay thinnest where the Kelloway rock was thickest, and *vice versâ;* but was, as far as can be told, nowhere absent. In the Yorkshire basin, however, where the deposits had been so thick, the deposition seems to have rapidly overtaken the depression, and sand once more collected; and in the shallows towards the shore of the Pennine chain to be, corals established themselves. Colonies of these zoophytes also established themselves further west, where Hackness is now; but in the deeper waters towards the south, where but little deposit had previously taken place, not the sign of a coral ever appeared, but the clay kept falling down in a dull monotony.

The Yorkshire basin now once more began to teem with marine life, which had so long been almost deprived of it; and spite of its more northern climate, developed masses of limestone from the worn-down fragments of corals living near the spot that put to shame the products of the tiny reefs of

the south. Accumulations of oolite, reaching in Riccaldale as much as 150 ft., were derived from this source, though the homes of the corals themselves are swept away. An inundation of sand, however, once more interfered with its tranquil formation, and, as the middle calcareous grit, separated one coral growth from another. Then came the coralline oolite, still derived from localities now unknown. From their thickening, however, towards the centre of the Pickering valley, we may conclude that the coral reefs themselves stood somewhere within the confines of that valley; and this is rendered more probable as it is round its edges that we find them still left *in situ* where they spread outwards and covered the old deposits. The luxuriousness of their growth was marvellous; and the profusion of life which accompanied them, or dwelt in snug nooks in their neighbourhood—such as where North Grimston now is—was not far from equal to that of the tropics of to-day. In this area undoubtedly flourished the finest coral reefs that England has ever seen since the period of the Oolites of Bath.

Curious changes have passed upon some of these rocks since then, the origin of which is difficult to account for. Instead of their original calcareous material, an enormous amount of silex has been introduced, turning an oolite into a silicious rock in some places, developing great flints in others. The calcareous matter of the middle grits has in like manner been totally extracted, leaving but a skeleton of sand behind. These changes have taken place to so complete an extent, that were the silex removed, scarcely any rock would now be left. Hence the infiltrating mineral could not have come from the rock itself; and however we may try to explain the origin of flint in chalk by means of the sponge specules, and other silicious bodies it originally contained, some other method of interpretation must be adopted here. But to continue the history.

After the long continuance of the colonies of corals on the Pickering area, those changes began to take place which led to the alteration in character between the Kimmeridge and Oxford clays; and the corals became choked with inroads of sands and clay, coming apparently from many directions, and therefore local and variable. In the ups and downs, the shifting and changing of currents, local beds were no doubt denuded, and their remains deposited in shoaly water. But after these minor preludes, that great continued era of depression set in steadily which enabled the great thicknesses of Kimmeridge clay to be here and elsewhere all alike deposited. The widespread common features of this formation, as seen not only in Yorkshire but in Lincolnshire, and still further to the south, forbid us to look to any local source for the sediment required; rather we must go back once more to the coal measures, which throughout their range must now have been well exposed to the action of the rivers, draining into an open sea, and limiting them ultimately to nearly their present boundaries. The great masses of argillaceous matter thus derived sank slowly and uniformly in an ever-deepening sea, at first shallow enough to encourage the growth of the great deltoid oyster of the period, but soon becoming the resting-place of the more pelagic cephalopods, and comparatively barren of life. Thus at least 500 feet and more, probably 1,000 feet, were left behind. But just as the coral reefs of Yorkshire were formed, whilst many other places were receiving only the *debris* of carboniferous shales in their open sea, so now, by a change of turn, Yorkshire continued to receive its clay deposits while Portlandian reefs were formed in the south. These clays we find at Speeton, a locality of great importance to our history. In this way, then, Yorkshire continued without change to the close of the Jurassic period.

We now enter upon a portion of the history which is

rather more obscure, as gathered from what is absent rather than from what is present.

I have suggested that the coral reefs whence the coralline oolite was derived might have stood on the Pickering valley; but this requires some explanation. By what has been already noticed respecting the older Oolitic rocks, it is seen that this is somewhere not far removed from the line of minimum deposition, so that the sea bottom would represent somewhat of a basin-shaped area, and it would be round the edges of this that coral growth would flourish, taking a wider and wider circle round the vale as the base went down. Thus, from the wearing away of the old coral reefs, and then spreading outwards, the more central portion would be left weaker, like a lagoon, and perhaps entirely deprived of its original coral growths. Whether any such is to be found beneath the Kimmeridge clay of the vale of Pickering yet remains to be proved. In any case, this central line from east to west, after the deposition of the Kimmeridge clay, was one of weakness, not of strength; and when the great upheaving forces once more came into action, and the whole of East Yorkshire was raised above the level of the sea, the massive gave way here, and produced along the vale of Pickering, westward to Coxwold and Topcliffe, that scene of wild geological confusion which has long been, and long will be, a puzzle to students to understand. Along the north side is a great Fault, and along the south side is a great Fault, or more than one, and into the huge cleft the Kimmeridge clay sank bodily down. But for that deposit the vale of Pickering would be a fearful chasm, with precipitous sides, 500 feet in depth. On going west, where the great dislocation struggled with harder rocks, they were tipped over on their edges and let down into the gulf below, and thus we find —here a piece of calcareous grit, here a piece of Inferior Oolite surrounded by the clays of the Lower Lias, and

still further west, a mass of the Lias let down into the Trias below.

It was now the turn of Yorkshire to be denuded, and to pass on to other districts the materials it had so richly gathered. While the central portion, protected, as has just been explained, by the very catastrophe which exposed the whole to denudation, escaped comparatively untouched, the two main anticlinal axes, one to the north, across the moorlands, and the other to the south, corresponding to the old line of elevation which originally gave Yorkshire its local character, suffered most severely. In the north the beds were worn away to so thin a substance that little was left as a cap above the Lias; and the denuding forces of later periods soon carved a way through it to produce the curious Liassic inliers of the moorland vales. On the south a clean sweep was made, and the old axis denuded to the Lower Lias. Not that much was required in the way of denuding, for the beds were very thin and many absent; but only here and there were remnants left to tell what once had been. In particular, the Kimmeridge clay, which must once have covered the whole area with no mean thickness, has only escaped here and there on the surface of the lower beds, as at Pickering, Helmsley, Malton, and Birdsal.

But what became of all this clay? By what must be considered almost an accident we are able to give some account of it. For at Speeton we just catch the corner, so to speak, of the great area where it went to rest. There, separated from the last of the Portlandian clays by nodules of phosphatic matter, such as are generally taken to be a sign of unconformity, we find a new series of *lower* Neocomian clays, nearly the only ones in this country, and which there can be but little doubt were derived from the denudation of the Kimmeridge clay of the elevated Yorkshire area, and which accounts for their local development. These are

followed by Middle and Upper Neocomian, and we thus learn that it took the whole of that period to entirely strip the surface of its covering. While, however, the rivers that led eastward were charged with argillaceous matter, those that ran southward, draining the southern axis in that direction, may have eaten through to the lower oolitic deposits, and have contributed in some degree to the calcareous rocks which are now the ironstones of the Middle Neocomian or Tealby series of Lincolnshire, and which probably extended at one time into Yorkshire.

At the end of the Neocomian period, East Yorkshire ceased to be local, and became for upper cretaceous deposits part of a wider area. The northern moorlands may have still remained above the sea when depression once more set in, as there is no proof that the chalk was ever there, and much against its having been; but the southern axis was submerged, and disappeared from importance for a time, opening the area from the vale of Pickering southwards into the great sea which stretched eastwards to North-west Germany and southwards as far as the Wash. This sea was shallow, and hardly any deposit was formed in it, and it was separated from the southern seas by a barrier like that which once separated Yorkshire. While to the south the denudation of the Kimmeridge clay—interrupted for a while by the configuration of the country, which led first to the Wealden deposits, and then to Lower Greensand, all in comparatively shallow water—was continuing, and Gault was being formed, the more northern sea was at rest, and only accumulating a few feet of red chalk, whose colour may be due to the deposit of various ferruginous compounds during its very slow formation. When this red chalk first commenced seems to be a disputed point; nor can it be absolutely decided. The area of its deposit was itself formed after the last of the Neocomian beds, as we learn at Speeton; but how soon after,

or whether it began immediately to receive its sediment, we cannot be certain. The little Belemnite which so eminently characterises it is found throughout the Gault, and the Ammonites of both Upper and Lower Gault are found in it. Nevertheless, the red chalk lies over some of the Gault near Lynn, showing at least that it did not spread to *that* spot till a somewhat later time. But whenever it first began to be formed, we can have no good reason to doubt its uniform continuance; and as it is the only bed we have in Yorkshire to represent the other southern deposits of the Upper Greensand and Chloritic Marl, it must have certainly been contemporaneous with them also.

After having thus been long stationary, the large area in question at length gradually sank, soon after the commencement of that wonderful epoch when the chalk was formed. It then became one with the area to the south, and the two make one consistent whole; and yet, notwithstanding their general unity, the northern district, including the Yorkshire part of it, still remained distinct in minor matters; and its organic remains are to be matched, not so much to the south, as to the east in Germany, where the red chalk also preceded their enclosing matrix.

Such is the last of the solid rocks which form the backbone of the moors and wolds; and East Yorkshire's history, since the time of its formation, has been one of loss and trouble—losses, however, which have carved it into beauty, and troubles which are an endless source of interest to the student of glacial phenomena.

When the next elevation took place, the northern heights had not probably far to rise, and the southern ones came up on their old axis; so that where the underlying rocks are most absent, there the chalk is highest above the sea. This elevation, with its natural dip towards the east, gives to the chalk its present position. It was no doubt in this elevation

that the Howardian hills, so often disturbed and dislocated, could hold together no longer, but opened that remarkable gap by which the water which drains off the moorlands, collecting in the vale of Pickering, is carried off by the Derwent to the south. It might perhaps be thought by some that we have here another example, like that of the Weald, of the transverse valleys having been worn out when the centre was at a higher elevation than the surrounding country. This, however, with the highest formation in the centre, and that let down by Faults, is here impossible. The line of the valley south of Malton probably is also a Fault, or due to several. The way in which the inliers of Bransdale, Farndale, and Rosedale have been formed is probably this. The water originally flowing over the natural slope of the country, would find sandstones on the high ground, but on nearing the vale of Pickering, would eat into the calcareous rocks with greater rapidity, thus producing the mouths of the valleys, and adding force to the fall of the water above by shortening its length of flow to the lower level; so it would at length work its way downwards, till, when it reached the Lias, the yielding shales would soon enable it to scoop out a wider valley. In the northern valleys the capping of Inferior Oolite is so thin that it is only due to undulations and Faults in the strata, which here and there bring the upper beds down into the way of the stream, that the whole of them is not one long valley simply worn down into the Lias, and having its *embouchure* at Whitby.

The effect of the glacial epoch on East Yorkshire is fairly well marked. The rocks, indeed, are not of a character that would preserve any glacial striæ, and none to my knowledge have ever been found. The rounded surface, however, of some portions of the basaltic dyke almost call a *roche moutonnée* to mind. The larger number of effects, however, are those produced while the land was submerged. In the northern

districts, the great deposits of boulder clay do not reach a height of more than 350 feet, and valleys above that elevation are free from it; but those below that depth were utterly obliterated by it. In some instances the new valleys run in the same lines as the old, but often the old valleys are still blocked up, and new ones run by their side or across them. Sometimes a double valley is formed on the two sides of the old one, leaving a long tongue of glacial material between. In the area of the chalk the phenomena are somewhat different, for the floating ice seems here and there to have caught the surface and torn it up and contorted it in a wonderful manner, while the relics of remote strata brought by the ice are left at higher elevations, and have a rather different character from the usual boulder clay, and appear to have been largely derived from the Lias, both on account of their mineralogical character and contained fossils. Into the formation of the several beds which constitute the Holderness, or the various deposits which stud the vale of York and bury its Triassic basis beneath 50 to 100 feet of superficial accumulations, some with the relics of mammals, some collected in the wildest confusion, and some tranquilly reposing clays or soft sands with remains of forest growth, I will not now enter, as I feel that there are others who are much more competent to deal with these matters than myself; but must content myself with the above brief outline of those geological changes which have made East Yorkshire what it is, and have brought into existence those rocks on which the glacial agents have acted, and given their final touches to the scenes.

ON THE RED CHALK. BY THE REV. E. MAULE COLE, M.A., &c.

The subject of this paper is the Red Chalk, a formation peculiar to the East Riding of Yorkshire, Lincolnshire, and a small portion of Norfolk. Years ago it attracted so little notice, that Professor Phillips, in his second edition of the "Geology of the Yorkshire Coast," 1835, disposed of it in three or four lines, and only mentioned its occurrence at Speeton. Since then the Rev. T. Wiltshire, F.G.S., has published a paper on the "Red Chalk;" and within the last few months, the Rev. J. F. Blake, F.G.S., has published, in the Proceedings of the Geologists' Association, an exhaustive paper on the "Chalk of Yorkshire."

After this latter excellent treatise, there is really little to be added; and were it not for the fact that my engagement was made prior to the appearance of Mr. Blake's paper, I should not have ventured to say anything on the subject. All that I can do now is to contribute mainly what little information I can from my own local knowledge; and however humble this may be, I venture to affirm that it is not altogether unimportant, because local observers have better facilities for studying their own immediate neighbourhoods than those whose time and occupation only allow them to pay flying visits.

But first, it must strike every student of Geology what vast gaps there are in the cretaceous formations of Yorkshire, as compared with similar formations in the south of England. The lower cretaceous group, otherwise called Neocomian, consisting of *Lower Greensand* (800 ft. thick), *Weald Clay* (600 ft.), and *Hastings Sands* (900 ft.), amounting altogether to a depth of 2,300 ft., is wanting in Yorkshire, except so far as represented by the Speeton clay, which is supposed to be a marine equivalent of the freshwater deposits of the

south. And the *Chalk Marl, Upper Greensand,* and *Gault,* amounting in the south to some 400 ft. altogether, are but slightly represented in the north by a band of red or grey chalk, seldom exceeding 40 ft., and a small patch of Upper Greensand in the neighbourhood of Welton.

It is to this red or grey chalk that your attention is directed. It lies at the base of the white chalk, and is absolutely flintless. As a rule it follows the contour of the Chalk Wolds on their northern and western escarpments, and is so delineated by Professor Phillips. From the accumulation of surface soil, it can only be seen *in situ* in a few places; but its locality may be infallibly determined by the numerous springs which issue from its junction with the Speeton or Kimmeridge clay beneath. Being for the most part a comparatively thin deposit, its chief importance lies in the fact that by it we are enabled to trace the elevation of the base of the true chalk, above the vale of Pickering on the north, and the vale of York on the west, and consequently the thickness of the chalk at points of its highest elevation.

Many persons glancing at a physical map, or obtaining a view of the precipitous sides of the wolds from the railway from York to Scarbro', might suppose that the hills were composed of chalk to their base.

But this is not so; it is only at the two extremities, at Speeton on the one hand, and near the Humber on the other, that the red chalk comes down to the level of the plain. At the north-west corner of the wolds, from above North Grimston, round by Acklam, to Kirby Underdale and Bishop Witton, the red chalk lies at an average elevation of about 450 ft. above the sea level; so that the outer hills are only capped with chalk, the base being composed of Kimmeridge clay and Corallian rocks.

It is clear, in fact, that the chalk is thinnest at its

highest elevation, and increases in thickness, in a line drawn from the north-west corner of the wolds to Hornsea in Holderness, where it is 800 ft. thick, at a depth of 135 ft. below the surface of the boulder clay. (Compare section 5.)

The thinness of the chalk at high elevations is shown in the four following sections, each about $1\frac{3}{4}$ miles in length.

The first (1) is from the Cement Stone Quarry, figured in Messrs. Blake & Huddlestone's "Corallian Rocks," p. 375, to Duggleby, in a direction due east.

The second (2) is from Wharram Percy Church to a pond and springs, close to Burdale Station, in a direction south by east.

The third (3) from Bishop Witton to Whitekeld Dale, near Givendale, direction east.

The fourth (4) from a spring on the Kilnwick Percy Hill, which supplies Admiral Duncombe's house, to the pond in Warter village, direction east.

In the first, the grey chalk is highest at the west end, 450 ft., and appears at 375 ft. at the east end. The white chalk, in the hill above called the Peak, attains a height of 561 ft., and is therefore only about 150 ft. thick. In the second, the red chalk dips from 450 ft. to 338 ft., whilst the summit of the intermediate hill is 675 ft. So that a thickness of nearly 300 ft. might be assigned to the white chalk, were it not for another fact brought to light by the boring of Burdale Tunnel, adjoining the line of section. This tunnel, one mile long, was bored almost throughout its entire length in Kimmeridge clay. At the south, or Burdale end, the railway enters the tunnel at an elevation of 400 ft., and with an incline of 1 in 70. This would make the elevation of the railway towards the centre about 440 ft., whereas the highest point on the surface is only 660 ft. So that, what with the height of the tunnel itself, wholly bored here in Kimmeridge clay, it may be confidently asserted that 200 ft.

is the maximum thickness of the chalk at this highest range of elevation.

In the third section, above Bishop Witton, the red chalk at its outer margin appears at a level of 475 ft. above the sea. A mile and a half farther east, in Deepdale, it crops out at 375 ft., the intervening hill rising to 675 ft., thus giving some 250 ft. for the extreme thickness of the white chalk at its highest elevation.

In the fourth section, with the exception of the 100 ft. at the highest point, there is scarcely any white chalk at all, the red layers coming continually to the surface.

At Huggate, five miles south of Burdale, distant five miles from the outer edge of the wolds, and twenty from Hornsea, at an elevation of 500 ft., about the sea level, the chalk is 339 ft. thick, as might be expected from the accompanying section. (Section 5.) But a more interesting fact remains for notice.

Two or three years ago I inspected a geological map of the wolds at the Jermyn Street Museum. The line of the red chalk was marked on the *outer*, *i.e.*, the *northern* and *western* sides of the wolds only. No one seemed to have any idea that the red chalk occurs on the *inner* or eastern side of the highest range. But it does undoubtedly at Burdale Station, where it may be seen at the bottom of the hill by the pond, exposed 6 or 7 ft. thick. The grey chalk appears also on the east side at Duggleby, the head of the great wold valley which runs to Bridlington, and also in a Slack, called Nova, some half-mile to the south, where there are springs. There is also every reason to suppose that it might be found in many parts of Thixendale valley, especially near Brownmoor.

It seems then that the chalk of Yorkshire somewhat resembles a basin, or rather portion of a basin; that the rim, which is now the thinnest portion, owing to subaerial

denudation, has been raised highest by subterranean forces; and that this action found its fullest development in the neighbourhood of the valley from North Grimston to Wharram and Burdale Tunnel, which valley is probably due to a crack or fissure, produced by upheaval and tension of the superincumbent beds. Denudation has worn down the sides, but not equally. On the east side of the valley, the grey chalk appears at an almost uniform level of 400 ft.; whereas on the west side it attains a height of 475 ft. Consequently a larger portion of Kimmeridge clay is exposed on the west side than on the east; and this has wasted away, and presents a more sloping surface than the chalk on the east.

I have used the terms *red* and *grey* chalk indiscriminately, because I believe that many beds which present no traces of red colour belong to this formation.

At the north end of Burdale tunnel there is a deposit of upwards of 20 ft., similar in texture to the red chalk of Speeton, with no trace of flint, of a greyish colour, and showing, when broken, rich chocolate markings, resembling the black spots indicating Manganese. It contains terebratulæ, but of a much smaller kind than those found so abundantly at Speeton. A similar formation, or rather the same, appears at another point nearer North Grimston, exposed for a length of several hundred yards on the same east side of the valley. On the west side it also appears at the base of the chalk, opposite Wharram station (where there are springs at an elevation of 475 ft.), with the same peculiar markings. It occurs also at Duggleby and Nova. It is not white chalk; it cannot be called chalk marl exactly, though at Nova and other places it is friable and clayish; but it must be the equivalent of the formations known in the south under the terms Chalk Marl, Upper Greensand, and Gault.

In fact, since writing the above, I have satisfied myself that the grey and red chalk are parts of the same forma-

tion, because on examining again more minutely the red chalk developed at Warter (distant three miles from Nunburnholme Station) I found an upper bed of grey chalk, very friable, with the same terebratulæ and chocolate markings as occur in the Wharram valley, of unascertained thickness, followed by a bed of red chalk, almost clay, 6 or 7 ft. thick, containing spines of Echini; then a bed of grey chalk, containing a remarkably hard seam; then more red chalk, very friable; and so on for 25 ft. at least, and at the base a bed or vein of red chalk, quite unique. At least, I have never seen the like, either for richness of colour, for extreme hardness and weight, or for the importance of the contents.* The fossils are thickly scattered, and are all belemnites. I forwarded some specimens to Professor Rupert Jones, F.G.S., and he reports, as regards the minerals, after a hurried examination, that the specimens contain—1, Smooth, subangular, and rounded bits of ironstone; and 2, Crystallised nests of calcite. I am of opinion that a closer examination of *all* the specimens (only a few small ones were forwarded to Professor Rupert Jones) will disclose fragments of other minerals; and if so, will form an interesting comparison with the observations of Mr. Murray on volcanic products in the red clay of the Atlantic, mentioned below.

The beds above noticed crop out in a cutting on the road side, at the bottom of the hill leading from Warter to Huggate. The rich, red bed (elevation 200 ft.) is close to the blacksmith's shop, before turning the corner to ascend the hill, and is on the floor of the road itself. Close by are some beautiful springs issuing from the base of a sort of inland cliff. The road hence to Warter Priory repeatedly cuts through beds of red chalk which are clearly exposed;

* The same bed, however, occurs at Millington Springs, distant two and a half miles north, containing innumerable belemnites, iron ore, and large terebratulæ, but it is not quite so red.

e.g. one opposite the church before reaching the village green (elevation 198 ft.), and another a little further on, under the National School, at an elevation of 224 ft. A grand section (Section 6) may be seen in the brickyard adjoining Warter, on the road to Pocklington (elevation 275 ft.) Here the colours are remarkable. Under the surface soil is a band of grey chalk, from 1 ft. to 2 ft. thick; then red chalk (1 ft.) of various hues, occasionally pink, full of iron nodules; followed by a band of orange-coloured clay (1 ft.); and this again by grey clay tinged with light blue (1½ ft.) Underneath is exposed the Lias.

The *colour* of red chalk is very variable. At Speeton it is rich in colour, as in fossils. It is also fairly bright just below Acklam brow (the finest view in East Yorkshire), where it is well developed, above some springs, bordered by willows. At Burdale Station, and in two dales near Wharram Percy Church, it has a duller colour, whilst there is no trace of red colour in the valley north of Burdale tunnel. It is brightest of all in Warter, in the hard bed above mentioned; though even here, in the upper beds, the colour fades to a very slight tinge of pink. The colour at Millington Springs is also darker than at Speeton, and most resembles the beds at Warter, distant only two and a half miles. At the Warter brickyard, the colour occasionally resembles magenta.

Whether the colour was introduced at the time of deposition or subsequently, is a question hitherto, I believe, unsettled. I am inclined to think subsequently. Certainly at Warter there are alternate beds of red and grey chalk, and even in the same piece of chalk the red colour is found at the top and the grey at the bottom, without any apparent distinct line of separation; and in fossils in my possession, taken from the actual red chalk of Speeton, the interior filling of the shell is grey, not red, as if the shell had prevented the colouring matter from entering.

On the other hand, the fact remains that by far the richest colouring is in the lowest bed, described above, which agrees with the results of the "Challenger" Expedition. These results may possibly throw some light on the phenomenon of red chalk. It appears that a chalk formation is going on at the present time in the basin of the Atlantic, and that at a depth downwards from 2,300 fathoms, red clay was invariably found, instead of Globegerina ooze.* The Globegerina ooze contains some 98 per cent. of carbonate of lime, and is therefore a true chalk formation. It is followed at depths varying from 2,100 to 2,300 fathoms by a grey ooze with less lime, and this in turn, at all greater depths, by red clay.

It has been suggested that the solvent power of sea-water at great depths acts upon the calcareous skeletons of Foraminifera, and decomposes them entirely. This accounts for the absence of lime, but not for the presence of the red colour.

According to Mr. Murray,† one of the civilian scientific staff of the Expedition, Manganese peroxide is abundant in the red clay of the Atlantic, and is a volcanic product. Sir Wyville Thomson‡ considers that the red clay of the Atlantic is the insoluble residue—the *ash*—of the calcareous organisms which form the Globegerina ooze, after the calcareous matter has been by some means removed. He describes this "ash" § as consisting of 1 per cent. of peroxide of iron and alumina and silica, left behind after removal of the lime by carbolic acid, with which the water is charged.

With reference to the minerals mentioned above, as

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* The following remarks are principally suggested by the similarity of colour and position. Of course red chalk is not the same as red clay, but as above mentioned, some of the beds, notably at Warter, contain far more alumina than carbonate of lime.

† Voyage of the "Challenger." Vol. i., 230.

‡ *Ibid.*, Vol. i., 229.

§ *Ibid.*, Vol. i., 316.

possibly occurring in the hard bed at Warter and Millington, the following passages are interesting:—

"Everywhere in the Globegerina ooze, Mr. Murray has detected, in addition to the Foraminifera which make up the great part of its bulk, fragments of pumice, minute fragments of felspar, particles of crystals of other minerals, due to the disintegration of volcanic rocks, such as sarridine, augite, hornblende, quartz, leucite, and magnetite, and rounded concretions of a mixture of the peroxides of manganese and iron."*

"Over the red clay area the pieces of pumice and recognisable mineral fragments were found in greater abundance."†

Whether the specimens exhibited show a similar state of things in past ages, I am not competent to say; but I venture to suggest that it is a point worth inquiring into.

In conclusion, I may add that I have noticed on Monte Generoso, in Italy, between the lakes of Como and Lugano, a remarkable similarity to white and red chalk, in a formation which I imagine to be Dolomite, where the lower beds for some 40 ft. or more are of rich red colour, and the upper as white as white chalk. Curiously enough, there is a spring at the base. The formation can be well seen at an elevation of 3,000 ft., at the commencement of the zigzags which, after one and a half hours' walking from Mendrisio, lead up to Dr. Pasta's Hotel on the summit (half-an-hour).

It appears, on the whole, that from some cause or other, *red layers* must, as a rule, be looked for at the *bottom of a formation.*

As regards fossils in the red chalk, I have been able to find very few, except at Speeton, Warter, and Millington. At the former place, on the shore, any amount of Belemnites minimus, and various Terebratulæ, especially T. biplicata, may be found in a short time; also spines of Echini, chiefly

* Voyage of the "Challenger" Vol. ii., 295. † *Ibid.*, Vol. ii., 296.

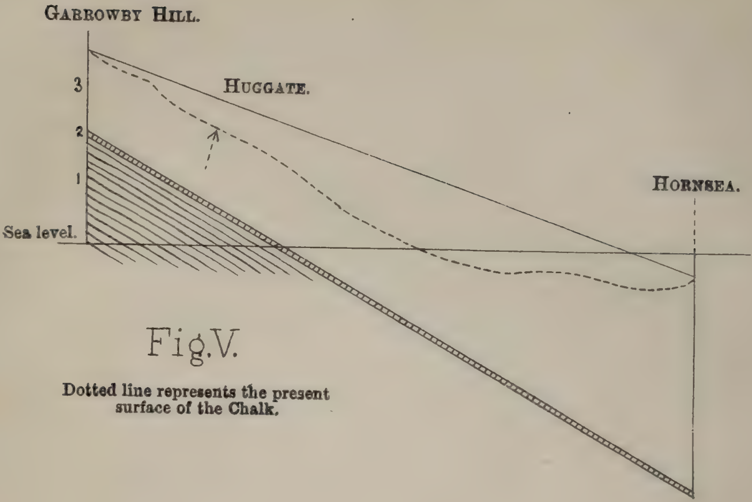
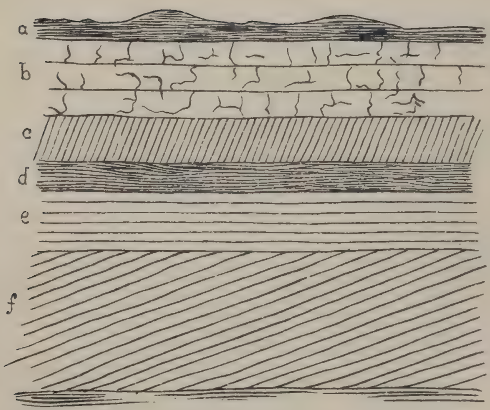


Fig.V.

Dotted line represents the present surface of the Chalk.



Fig, VI. Section in Warter Brickyard.

Sections in the Red Chalk, Yorkshire.

McCorquodale & Co., Lithographers, Leeds

Proc. York. Geol. and Polyt. Soc., N. S. Vol. VII., Pl. I.

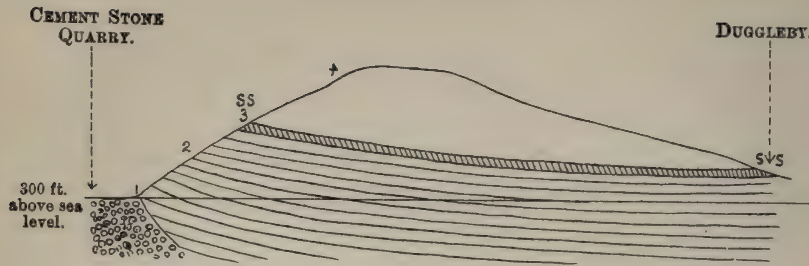


Fig. I.

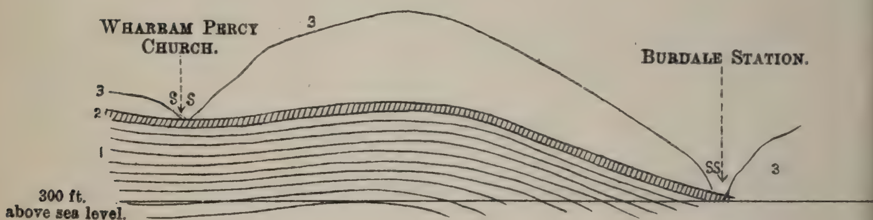


Fig. II.

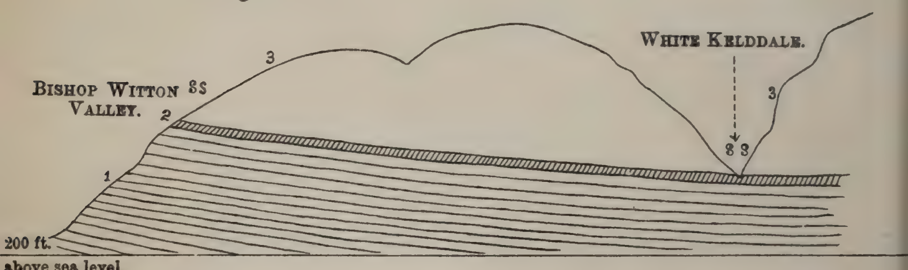


Fig. III.

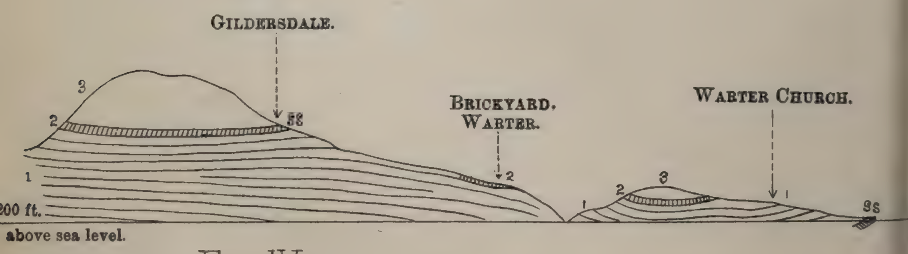


Fig. IV.

SECTIONS IN THE RED CHALK, YORKSHIRE.

McCorquodale & Co., Lithographers, Leeds

Cidaris sceptrifera, and peculiar stems, probably of sponges or fucoids, resembling a small branch of a tree. At Warter, the upper red and grey beds yield numerous small Terebratulæ, mostly T. semiglobosa, one very minute, known as Terebratulina gracilis; also spines of Echini, and two forms of Rhynchonella, *Sulcata* and *Martini;* and the hard red band at the base is full of Belemnites, as is the case also at Millington springs. On the whole, the red chalk is, comparatively, far richer in fossils than the white.

EXPLANATION OF PLATES.

Plate I.

Fig. 1.—Section from Cement-Stone Quarry to Duggleby.

1. Supracoralline Beds.	4. White Chalk.
2. Kimmeridge Clay.	SS. Springs.
3. Red or Grey Chalk.	

Scale—2 in. to a mile. Verticle—¼ in. to 100 feet.

Fig. 2.—Section from Wharram Percy Church to Burdale Station.

1. Kimmeridge Clay.	3. White Chalk.
2. Red Chalk.	SS. Springs.

Scale—2 in. to a mile. Verticle—¼ in. to 100 feet.

Fig. 3.—Section from Village of Bishop Witton to Whitekeld Dale.

1. Kimmeridge Clay.	3. White Chalk.
2. Red or Grey Chalk.	SS. Springs.

Scale—2 in. to a mile. Verticle—¼ in. to 100 feet.

Fig. 4.—Section from Kilnwick Percy House to Warter Church.

1. Kimmeridge Clay.	3. White Chalk.
2. Red Chalk.	SS. Springs.

Scale—2 in. to a mile. Verticle—¼ in. to 100 feet.

Plate II.

Fig. 5.—Section from Garrowby Hill to Hornsea.

1. Kimmeridge Clay.	3. White Chalk.
2. Red Chalk.	

Scale—⅛ in. to a mile. Verticle—⅛ in. to 100 feet.

Fig. 6.—Section in Warter Brickyard.

	Ft.	In.		Ft.	In.
a. Surface Soil, .	0	4	*d.* Bright Orange Clay,	0	10
b. Grey Chalk, . .	1	6	*e.* Bluish White Clay,	1	3
c. Red Chalk, . .	1	0	*f.* Lias, ...	3	0

ON THE OCCURRENCE OF CERTAIN FISH-REMAINS IN THE COAL MEASURES, AND THE EVIDENCE THEY AFFORD OF FRESH-WATER ORIGIN. BY JAMES W. DAVIS, F.G.S., L.S.

The objects of this communication are—First, to describe a bed of Cannel or Stone Coal existing over a limited area in the West Riding of Yorkshire, and enumerate the remains of Fossil Fish which occur in the coal and immediately above it; and secondly, to consider the relation of these fishes to each other, and the evidence they afford as to the circumstances attending their deposition.

The Adwalton Stone Coal is situated 400 to 420 feet above the Blocking or Silkstone Coal, the latter being taken as the division between the Middle and Lower Coal Measures, in accordance with the printed memoirs of the Geological Survey. The Stone Coal is worked, or has been, over an area of about 16 to 20 square miles, at Carlinghow, Gildersome, Bruntcliffe, Morley, Tingley, and Ardsley, all being a few miles south-west of Leeds. The surface in this district is characterised by thick beds of a fine-grained sandstone, the Thornhill or Dewsbury Rock, which forms a plateau along the tops of the hills, with a slight inclination to the south-east. The even slope of this rock is intersected by deep valleys formed by the action of numerous streams still running in them. The cannel coal lies at a varying depth below the surface relatively to the position which the pit occupies, being about 200 feet at Ardsley, and at Bruntcliffe 250; whilst at Carlinghow and Gildersome, the pits being sunk in the valley, the depth is only 50 feet.

The following section may be of service in showing the vertical position of the coal:—

	FT.	IN.
Thornhill Rock	120	0
Blue Argillaceous Shale	16	0
JOAN COAL	1	6½
Blue Argillaceous Shale	24	0
COAL	0	10
Seat Earth	6	0
Blue Shale, with layers of Ironstone ...	13	0
White Earth, with bands of Ironstone ...	7	0
Black Shale, with Anthracosia	3	0
Adwalton Stone Coal	1	10
Seat Earth	2	0
Strong White Stone	17	0
Blue Shale	4	0
BLACK COAL	0	7
White Stone and Shale	31	0
FORTY-YARDS COAL	3	0
Seat Earth	3	0
Blue Shales, &c.	43	0
FIRST BROWN METAL COAL	2	0
Strong Sandy Shale	24	0
SECOND BROWN METAL COAL	1	10
Seat Earth	3	0
Soft Blue Shale, with Ironstone	10	0
COAL...	0	9
Blue Shale and Ironstone	25	0
Sandstone	20	0
Blue Shale	12	0
MIDDLETON LITTLE COAL	2	10
Seat Earth	4	0
Measures	75	0
MIDDLETON MAIN COAL	4	8½
Measures	40	0
Middleton Eleven-yards Coal	2	6½
Measures	40	0
BLOCKING COAL (or SILKSTONE) ...	3	4

The Adwalton Stone Coal or Blendings consists of two or more thin beds of cannel coal, with partings of shales more or less bituminous, and occasionally interbedded with thin

layers of seat earth or spavin. The section at Tingley exhibits the following series :—

	FT.	IN.
Whitish Claystone, with Plants and Unios.		
Unio-bed	0	8
Ironstone, with Unios	0	4
"Drub" or "Hubb"	0	1
Stone or Cannel Coal	0	6
"Drub" or "Hubb"	0	2
Dirt	0	2
Common Coal	0	3
Drubby Stone Coal	0	5
Black Shale	0	3
	2	10

At Carlinghow, two miles and a half west-south-west, the coal consists of—

	FT.	IN.
Stone Coal	1	3
Coal	0	2½
Shale and Coal	0	9½
White Earth	0	7
Black Coal	1	0
	3	10

At Adwalton and Gildersome, the cannel or stone coal is 9½ inches thick, and with common coal and bituminous shale reaches the aggregate thickness of a little over four feet. From this district as a centre, the stone coal becomes much reduced in every direction, and finally disappears. At Middleton, a mile and a half north-east of Tingley, the coal has thinned out as shown in the following section, given to me by Mr. T. W. Embleton :—

	FT.	IN.
Bituminous Shale	0	4
Cannel Coal	0	1½
Common Coal	0	9½
Cannel Coal	0	1
Common Coal	0	2½
	1	6½

The cannel coal has here become diminished to two thin seams, $1\frac{1}{2}$ inch and 1 inch thick respectively, and a little further eastwards, finally disappears, being replaced by a black bituminous shale. The stone coal is very fine-grained, bituminous, and of a dull black colour, lacking the shining fracture of the cannel of Lancashire. It is very homogeneous, and breaks with a concoidal fracture, mostly without a trace of the lines of deposition, and in this respect differing very much from common coal. The black bituminous shale, locally named "Drub" or "Hubb," is somewhat similar in appearance to the stone coal, and only differs from it in having a greater proportion of mud in its composition. It burns with a bright flame, and has been used in making gas for illuminating purposes, but leaves so very large percentage of ashes that it cannot be extensively used at the gasworks. In some instances it contains a quantity of mineral oil.

From a consideration of the above facts we are naturally led to think of the method of deposition of the substances forming the coal seam. The cannel coal being thickest in the centre, and thinning off in every direction, becoming less pure, and ultimately giving place to black carbonaceous shales, would appear to indicate that the plants were carried by streams into a quiet lake, where they became decomposed, and, settling to the bottom, accumulated as a homogeneous mass, prior to being changed by pressure and chemical causes into coal. The interlamination of shale, more frequent and thicker near the sides of the lake, would be the result of the mud, also brought by the streams, settling to the bottom quicker than the leaves and stems of the plants, but at the same time carrying down with it a good percentage of carbonaceous substances. Occasionally the lake appears to have been filled up, or elevated, above the water level, and seat earth, filled with rootlets of Stigmaria, has been the result. Above this are beds of ordinary coal, the plants

whose remains form the coal probably having grown on the site which it now occupies. We shall find, when the fossils are taken into consideration, that they also afford evidence largely tending to substantiate this theory.

Reverting to the general section already given, it will be seen that the varying alternations of shale, sandstone, and coal are repeated, with modifications according to the longer or shorter periods during which the land was submerged or elevated above the water—the shales indicating the period of greatest submergence; the sandstones being deposited above the shales, as we may naturally infer, near the shore, as the land was rising; and the coals being aggregated from the shedding of the spores or decay of the plants, in the situation where they grew, when the land was quite above water.

Whatever may have been the circumstances under which the Lower Coal Measures were formed, there can be little doubt that those higher in the series, of which we are now speaking, were accumulated in a large fresh-water lake, to which the sea *may*, during periods of more than usual depression, have had access. That marine conditions did prevail during the deposition of any part of the Middle Coal Measures in the West Riding, is, however, not a necessary supposition. This conclusion has been arrived at after a careful consideration of the general circumstances attending their deposition, but more especially, from the occurrence throughout the series of the fossil remains of fishes and mollusca of fresh-water types, and the number of impressions, most perfectly preserved, of the delicate fronds of ferns and other equally fragile plants. I do not intend to enter into any description of the deposition of the latter; but it does appear incompatible with our ordinary ideas of the result which might be expected, to suppose that the vegetable remains found so frequently in the shales, could be carried by rivers into the sea, subjected to some extent to the action of the waves or tides, and still sink

to the bottom and be as evenly and perfectly fossilized as though they had been carefully pressed for an herbarium. The most delicate specimens are always found in the shales composed of mud of the finest kind, and would consequently have the greatest distance to travel before reaching their destination, and pass through proportionate liability to destruction. In the coarser kinds of shale, well-preserved fronds are rare, and in the sandstones nearly or quite absent. The evidence afforded by the mollusca confirms the Fresh-water theory of deposition. In the case more especially under consideration of the Adwalton Stone Coal, there is, immediately above the cannel coal and "hubb," a bed of ironstone, four inches thick, containing Unios or Anthracosia; and then a bed, several inches thick, composed entirely of the remains of Anthracosia—higher up they become mixed with a black shale, two or three feet in thickness, and are fewer in number in the upper part. Above the black shale there occurs some twenty feet of whitish and blue shales, containing numerous bands of ironstone nodules. Shells of Anthracosia are common in the ironstone, but do not occur in the shale. This is exactly the state of things that might be expected to have taken place. After the accumulation of decaying vegetable matter, which formed the cannel or stone coal, there was a period during which a large percentage of mud was brought with the vegetable refuse, and being deposited together, the impure cannel coal, locally termed "hubb," was formed. Afterwards, from some cause, the amount of vegetable matter became less, and the muddy bottoms of the pools were thronged by immense numbers of molluscs, with thin bivalve shells, the fossil remains of which are always found more or less crushed. They are such shells as would be found at the present time inhabiting and luxuriating in semi-stagnant pools, weak and thin; sufficient to serve for the protection of the mollusc in a mass of soft mud, but totally

inadequate if we imagine them to have been the denizens of a marine estuary, or even of a quickly flowing river.

Higher in the series the black shale gives place to a whitish grey one, and the remains of the bivalves become much less frequent, and are only found preserved in the nodules of clay ironstone. Individual plant remains, reed-like in form and of large size, occur in abundance, their external part changed to a thin layer of bright glistening coal. The plants are always found laid horizontally, and never erect. They have evidently been conveyed by water to their present position. After the deposition of the shale with ironstone, the land re-emerged from the water, and a thickness of six feet of seat earth was formed, and on its surface a bed of coal of the ordinary kind. Then another submergence and deposition of 24 feet of shale, to be followed by a change of level, which again brought the land to the surface, and the Joan coal was accumulated.

The following list of fossil remains have been found in the Stone-Coal and the "Hubb," mixed indiscriminately :—

Cælacanthus lepturus, Agass.
Megalichthys Hibbertii, Agass.
Ctenodus elegans, tooth.
Rhizodopsis sp. ?
Diplodus Gibbosus, teeth.
Ctenoptychius, teeth.
Palœoniscus (Elonichthys) Egertoni.
Helodus simplex, Agass.
Gyracanthus formosus, Agass.
Ctenacanthus hybodoides, Egerton.
Two species not identified—spines.
Bones of Labyrinthodont.
Spirorbis carbonarious.
Entomostraca.
Unios, or Anthracosia.

In the West Riding, above many of the seams of coal at their junction with the shale, which usually succeeds next in

the vertical series, there is a stratum which contains fossil fish. The fish beds are generally of small extent, often less than one inch, rarely exceeding a few inches in thickness. The fish remains have been found in several instances in the Lower Coal Measures, as well as those higher in the series; notably above the Better Bed and Black Bed Coals in the Lower, and the Middleton Main Coal, the Yard Coal, and the Stone Coal in the Upper Measures. That the fish will be found to occur above other beds of coal, when due search shall have been made, appears very probable; they have not been recorded hitherto, because there has been no one sufficiently interested to make the necessary observations.

The fish remains belong to the Elasmobranchii and the Ganoidei; the latter very much prevailing both in point of numbers and frequency of occurrence.

One section of the Ganoids existing at the present time, represented by Lepidosteus, Amia, and Calamoichthys, are all fresh-water species, living in the rivers of Africa and America. Another large group, the Sturgeons, are denizens of alternately fresh, brackish, or salt water. The Ganoids of the Coal Period, represented by Megalichthys, Palœoniscus, Acrolepis, Platysomus, and Holoptychius, were probably more nearly allied to the fresh-water group than to the sturgeons; and it is a fair inference that they were fresh-water species.

The Elasmobranchii, consisting of the sharks and Rays, are generally found inhabiting salt water, and are essentially marine groups. There are, however, several instances on record in which they live in fresh water. Amongst others, they are said by Mr. T. Belt,* whose lamented death occurred so short a time ago, to occur frequently in the Lake of Nicaragua, in Central America; and they are common in some large rivers, such as the Ganges. If the instance cited by

* "Naturalist in Nicaragua," by Thomas Belt, F.G.S., &c.

Mr. Belt be thoroughly authentic, it is one of considerable importance. The lake, only separated by a strip of land from the Pacific, but not at present connected with that ocean, was probably in times past at a lower level, and formed an arm of the sea or bay, with a marine Fauna, no doubt including amongst other fish the sharks. As the land was elevated, and the sheet of water became isolated, it would become a salt-water lake in the first instance; but being fed by streams from the land, would gradually become less and less salt, until no trace of its marine origin remained. It will be a fair supposition, that the sharks, and perhaps other forms of animal life, would become denizens of the lake when it was first separated from the sea; and the inference necessarily follows, that as the lake became a fresh-water one, the sharks adapted themselves to their gradually changing environment, and are now existing in water without a trace of its marine origin.

If the supposed advent of the Nicaraguan sharks in the way sketched out be a reasonable one, as it appears to me, it leads to a probable corollary with respect to the occurrence of Elasmobranchs in association with the remains of the fresh-water Ganoids in the shales forming the roofs of the coal seams. It would not be an extraordinary supposition, that during the many and repeated elevations and submersions of the land during the Carboniferous Period, lakes originally containing salt water may have been changed to fresh water ones in the same manner as Lake Nicaragua; and fish, or other living organisms, have become adapted to live in either. A strong argument in support of the Elasmobranchs being at that time denizens of fresh water, may be adduced from the frequent occurrence of the remains of Labyrinthodonts and Dipnous fishes, in association with those of the sharks and Ganoids. The Labyrinthodonts were air breathers, and adapted for living on the muddy shores of rivers or lakes, as

well as in the water. Their fossil remains have been found in every instance, both in the Lower and Middle Coal Measures of Yorkshire, where the remains of fishes have been discovered. In nearly all cases, the bones, scales, or teeth of the fish and Labyrinthodonts are found mixed up promiscuously, often in a broken or fragmentary condition. Occasionally, however, specimens are found which are nearly or quite perfect, as, for example, the Pholiderpeton scutigerum, described by Prof. Huxley, from the Lower Coal Measures, near Bradford; and appear to have been buried in the mud near the place where they died.

The most remarkable circumstance respecting the cannel coal, north of Wakefield, is the occurrence of the remains of fossil fish, not only in the roof of the coal, but in numerous instances in the coal itself. The remains consist of spines and teeth of Elasmobranchs, and the scales, bones, and teeth of Ganoids; but the most important, as well as the most frequent fossil found, is that of Cœlacanthus. The remains of this fish occur in great perfection, but are nearly always broken in getting the coal, so that it is only with considerable labour that the specimens can be so joined together as to give a clear outline of its anatomy and form. Prof. Huxley, in the Decades of the Geological Survey,* and others, have pointed out the near relationship and the great similarity there is between the existing Lipidosiren and Ceratodus, or Mud fishes of Africa and Australia, and the extinct genus Cœlacanthus. They appear to have existed under very similar circumstances, living in swampy or marshy districts liable during certain periods to be dried up. When this occurs, we know the existing Dipnous fishes are provided with a swim-bladder, divided into segments by partitions along whose surface innumerable blood vessels ramify, and by means of which

* "Mem. of Geol. Survey."—Decade XII.

the fish can live through the long dry season. The recurrence of rain, softening the baked mud, is the signal for the semi-torpid mud fishes to emerge from their confinement: gradually the gills resume their function, and the swim-bladder is rendered useless for respiration and the purification of the blood until the next period of drought approaches.

Prof. Jobert, in a paper published in a recent number of the *Comptes Rendus*,* describing researches "On the Aerial Respiration of some Brazilian Fishes inhabiting Fresh Water," described the pneumatic bladder of certain Sirenoid fish—the Erythrini—as containing internally a number of cells, which are richly provided with blood vessels, and connected with the œsophagus. By means of this arrangement, the fish is able to support aerial respiration for a long period. These observations were made on fresh specimens; and it was further found, that by obstructing the opening from this air-bladder to the atmosphere, the death of the fish ensued. These fishes, which inhabit the Upper Amazon, may be frequently seen travelling from a dried-up pool, across the country in search of more congenial quarters; and during such excursions, the lung-like air-bladder serves all the purposes of respiration. The report concludes, "Nous voyons donc que le voyage de M. Jobert dans le vallée de la Haute-Amazone a déjà fourni à la zoologie physiologique des faits très-intéressants qui établissent de nouveaux liens entre les poissons ordinaires, les Lépidosiriens et les Batraciens pérennibranches, qui possedent à la fois des branchies et des poumons ordinaires. Les observations de M. Jobert sur la respiration intestinale des Callichthys ont non moins d'importance."

So far as the imperfect remains of the Cœlacanthoid fishes enable one to form an opinion, they appear to have existed under very similar circumstances during the deposi-

* *Comptes Rendus*, April 15th, 1878, p. 935.

tion of the cannel coal. They were possessed of an air-bladder, the remains of which is preserved in a fossil state. It has been described as osseous;* but after careful microscopical examination, no trace of osseous structure could be detected. The appearance is more nearly allied to chitine, but the want of good fossil examples of that substance for comparison leaves the question in a state of uncertainty. There can be little doubt, however, that the swim-bladder of the Cœlacanthus did serve a similar purpose to that of the Lepidosiren, Ceratodus, or the Sirenoid fish of the Amazon; and it is not probable that bony walls would assist it in the performance of this function, but rather retard the operation.

In the foregoing remarks an attempt has been made to show that fish may serve to indicate to a great extent the method of deposition of many of the varied beds which go to form the coal measures. In the case particularly cited, there is not only the evidence of the fish themselves, but also the coal and its immediately contiguous beds afford strong presumptive evidence that it was deposited in a semi-stagnant series of pools or small lakes, into which the vegetable matter was carried, whose decayed remains form the cannel coal, and when mixed with the mud also brought down with the vegetable matter, the "hubb." In the coal, as well as the "hubb," large numbers of Cœlacanths have been discovered; and along with these, though comparatively rare in comparison, are found the remains of Ganoids and Elasmobranchs. I have endeavoured to show that it requires no great stretch of scientific evidence to suppose that the Ganoids were fresh-water fish, as they mainly are at the present time; and that it is within the range of possibility that the sharks, during the Carboniferous Period, may have

* Mantell's "Petrifactions and their Teachings," 1851, p. 437. Prof. W. C. Williamson "On the Microscopical Structure of the Scale and Dermal Teeth of some Ganoid and Placoid Fishes," *Phil. Trans.* for 1849.

also flourished in the same medium. It is beyond the legitimate limits of this paper, or the argument deduced from the species of fish found in the Middle Coal Measures might be applied with equal force to those lower in the series, and usually called the Ganister Beds. The same species, almost without exception, are found to occur in every bed in which fish remains have been found, and would appear to have been aggregated under very similar circumstances in each case.

ON THE HISTORY AND OBJECTS OF THE SOCIETY, ESPECIALLY WITH REFERENCE TO THE HISTORY OF SELBY AND THE GEOLOGY OF SELBY AND THE DISTRICT.

BY J. T. ATKINSON, F.G.S.

Ladies and Gentlemen,—In the first place let me give you a hearty welcome to the good old town of Selby. I call it an old town because of our splendid Abbey Church, which was founded by St. Benedict upon land given by the Conqueror in 1069. The etymology of the name Selby has been a subject of controversy; but by many persons it is thought that the most probable derivation is "Sealby," that is to say, "the abode of the seals," because great quantities were captured here. The national events in the history of Selby are not numerous. It is asserted that the great battle between the Conqueror and the Saxon Earls Edwin and Morka took place here in 1068, when William gained the victory, and for a time triumphantly occupied York. In the following year, 1069, he founded the Abbey, and in 1070 brought his Queen to settle the endowment. Whilst at Selby his youngest son, afterwards Henry I., was born.

In 1643-4, during the civil wars, there were many skirmishes between the Royalists and the Parliamentary troops; several very sanguinary engagements took place, notably one on the 11th April, 1644, when the town was

attacked in three places by Cromwell's generals, the two Fairfaxes, and a cavalry engagement took place at the end of Ousegate, near the Station, when the Royalists were compelled to retreat to York with the loss of 1,600 men. This victory was the precursor of Marston Moor, and ended in the complete destruction of the Royalists' power in the north of England.

In 1774 a branch of the Aire and Calder Canal was opened, and was the means of creating a considerable amount of trade.

In 1834 the Hull and Selby Railway was opened, one of the earliest railways in the kingdom.

This is the first time that a purely scientific society has visited the town, but I trust it will not be the last. Doubtless the monks who built the splendid pile opposite, with a zeal and an ingenuity worthy of our most profound admiration, would to-day rejoice to see you assembled here to unfold some of the mysteries of nature, the antiquity and importance of which far surpassed even their efforts, but whose perseverance even we might well imitate.

With respect to our Abbey, I will not trespass upon your time in describing it, although by the second name of our title "Polytechnic," I might perhaps be justified; but I may remark that one of the earliest papers to this Society was contributed by Mr. Wm. Waller on "An Elucidation of the Geometrical Principles of Gothic Architecture." I will close this part of my subject by quoting the words of Dr. Freeman, one of our greatest living historical writers, who says,—"It may appear strange to claim the first place amongst the abbeys of Yorkshire for Selby. That great church has had the luck, good or bad, to be preserved in an almost perfect state. It is certain we have at Selby a foundation of the Conqueror which grew into a high position amongst the monastic houses of England, and to a specially

high position among the monastic houses of its own district, where it could have no rival of its own order except the house of St. Mary of York. Selby and St. Mary's stand alone in their own reputation as Benedictine houses of the first rank, and of these two, Selby stands alone as having its church preserved in an all but perfect state. And the Minster of Selby is in truth a building worthy of a unique position. In outline it is certainly lacking; the western towers were never carried up; the south transept is gone—the only mutilation of the church itself, as distinguished from the utter sweeping away of the conventual buildings which joined it on the south side." And even this mutilation was negative rather than positive. The ancient central tower fell in the year 1690, and crushed the south transept. The tower was rebuilt in the mean style of the time; the transept was not rebuilt at all. Down to that time the whole of the building must have been perfect. As we see it now, the general aspect of bulk and stateliness which is the impression the church gives at the first glimpse from the railway, is not belied on a nearer examination. In the lantern and surviving transept we have the remains of the original Norman building. The nave in its full length is one of the richest and most varied examples of the Transition, exhibiting a feature shared by some other churches of the same region. In single bay do the south side and the north agree. Some difference or other seems to have been studiously made between each arch and the arch opposite to it. It is this part of the building which supplies the greatest study of remarkable architectural forms. It is one which it would be instructive to compare with the contemporary nave of Worksop in the same diocese, though not in the same shire. But in most eyes the glory of Selby will be its choir, ending in a window which may claim at least the second place of its own class in England, and therefore in the world. Like

York, Lincoln, Ely, and Carlisle, Selby has neither apse nor lord-chapels spreading beyond the main building. The ends of the choir and its aisles form the grand and simple east end of a type exclusively English. Within, the choir may be thought to suffer somewhat from the common English fault of lowness. A somewhat larger triforum range would have made the difference; and the vault of wood is clearly the right thing if the walls and pillars were found unable to support a vault of stone. A wooden vault is of course a makeshift, but it is an allowable and necessary makeshift. The wooden vault of Selby is thoroughly good of its own kind, and it is a special relief to one who comes to it from the paltry roofs of its metropolitan neighbour at York.

This meeting is a very important one in the history of our Society, for it is the first meeting we have had since the name was changed from the West Riding Geological and Polytechnic Society to its present title. When it is considered what a large and important county Yorkshire is, how that it embraces within its boundaries so large a proportion of the Fossiliferous strata almost continuously from the Silurian rocks to the Chalk, and admits small tracks of shelly beds allied to the Crag, and broad spaces of glacial drift, besides marine and freshwater deposits rich in remains of Pleistocene age, I trust you will consider the determination a wise one. If, again, you regard its natural beauties, such as the moorland wastes, or its steep hills covered with foliage, or its sea-girt cliffs, or the rich alluvial soil seen in this neighbourhood, or the value of its mines and minerals; or again, the illustrious names it has contributed to the roll of fame and honour, such as our great Geologist, Father Smith, his illustrious nephew John Phillips, Sedgwick, the two Williamsons, Buckland, Scoresby, Hugh Strickland, West, Archdeacon Paley, Dean Howson, Sir Frederick

Leighton (recently elected President of the Royal Academy), Faraday, Captain Cook, and last, but not least, our afternoon President, H. C. Sorby, Esq., F.R.S., whose microscopical researches in mineralogy and geology have a world-wide renown, we may well be proud of belonging to such a county; and may we not hope that the golden age of Yorkshire is not over, and that even yet other names may be added to swell the list of illustrious Yorkshiremen.

It may interest you if I give a brief retrospect of the history of our Society. And here I must publicly express my thanks to our excellent Secretary, Mr. Davis, for the very valuable help he has given me in this part of my subject. The Society is now more purely scientific than it was formerly; a great part of the proceedings up to the year 1869 or 1870 were composed of papers, archæological rather than geological. There is now, however, a Yorkshire Archæological Society, which may be said to have sprung from our own.

The need of the Geological and Polytechnic Society is as great or greater at the present time than it ever was. Science makes rapid strides continually, and it is very desirable that means should be provided whereby the local or county questions relating thereto, often of very great national importance, commercially and socially, should be easily accessible to all interested. This is one of the characteristic features of our Society, and we aim at giving and affording means for discussion thereon.

The Society originated at a meeting of the West Riding coal proprietors on the 1st December, 1837; Thomas Wilson, Esq., of Barnsley, who afterwards became such an active member of our Society, occupying the chair. The vast importance of the Yorkshire Coal Field, occupying not less an area than 460 square miles, whether considered merely as a local question or as one of national importance, you cannot wonder at the formation of the Society. It was

thought that great advantage would result from the formation of the Society for collecting and recording geological and mechanical information with the accuracy and minuteness necessary for the successful prosecution of mining. These objects it was hoped would be most effectually attained by the formation of a collection of maps, plans, sections, models, mining records, and every kind of information respecting the geological structure of the country; the construction ultimately of a complete geological map or model; the formation of a museum, as well of the various fossils and mineral products of the district, as of drawings and models of the machinery and tools employed in mining; the consideration of the various systems of ventilation in use; the holding of public meetings in the principal towns of the West Riding, for reading communications and discussing topics connected with these subjects; the publication of papers, reports, and transactions, and the corresponding and co-operating with the metropolitan and other similar societies. While these subjects would occupy the principal attention of the Society, it was considered desirable (particularly as there was no other society embracing these objects) to extend its operations to whatever was connected with the staple manufactures of the West Riding, together with the bearings of geology and chemistry upon agriculture, and the application of mechanical inventions to the common arts of life.

The Society was at length formed, and the late Earl Fitzwilliam accepted the office of President, and was a great help to the infant Society. To trace the history of the Society would be to trace the history of the mining and iron district, not only in Yorkshire, but in England. A list of the papers read at the several meetings of the Society may be found in the Transactions for 1876, to which I beg to refer you.

Of the Presidents a few words may be interesting. Amongst the earliest to preside over us was Dr. Hook, the late Vicar of Leeds, whose scientific knowledge was as profound as his theology, and who will ever be remembered with gratitude by the Leeds people; another was Dr. Scoresby, the intrepid Arctic traveller, who was for seventeen years Vicar of Bradford; Mr. Hope Shaw, of Leeds, an eminent man of my own profession; Lord Houghton, whose services to England, whether as a statesman or a man of letters, are so well known; Mr. Thomas Wilson, who long served the Society in another capacity; the Rev. Josiah Bateman, an eminent minister. Of the Secretaries, I have already mentioned Mr. Wilson; then came the Rev. Mr. Thorp, who served the Society well; Mr. W. S. Ward, who also did the Society good service; and Professor Miall, whose services to biological science are so familiar to you; and lastly, our present Secretary, whose indefatigable exertions on our behalf are so well known.

Of the original founders of the Society, most have gone to their rest; but we have happily left to us Dr. Alexander, Messrs. T. W. Embleton, W. Sykes Ward, and R. Carter, all veterans who have done much good to the Society when it sorely needed help. To these Nestors of our Society our warmest thanks are due. Respecting the state of geology at this time, it may interest you if I say a few words. In 1838, Dr. Whewell was President of the Geological Society, and amongst the foremost members were Sir Charles Lyell, Buckland, Horner, Charles Darwin, Sir P. Egerton, Dr. Fitton, Ehrenburg, Sir R. Murchison, R. Owen, Henslow, Scrope, Dr. Babbington, Sir Abraham Hume, and Elie de Beaumont. Most of these are dead, but we have Sir P. Egerton, Darwin, and R. Owen. It was then that Professors Sedgwick and Murchison were engaged on their great work, the classification of the Cambrian and Silurian Rocks, which

was destined to immortalise their names. Then it was that geologists were divided into *Catastrophists*, or those who believed that the history of the earth was that of periods of repose alternating with catastrophes and cataclysms of a more or less violent character; and *Uniformatists*, or those who believed that, in spite of all apparent violations of the laws of continuity, the sequence of geological phenomena has really been a regular or uninterrupted one. Of the latter theory, which is now generally received, Sir Charles Lyell was the most distinguished advocate; of the former, Sir R. Murchison.

With respect to the geology of this district, very little need be said about it, as my friend Dr. Parsons has so ably treated the subject in his valuable paper, read before the Ripon meeting of this Society last year, "On the Strata of the lower Ouse Valley;" but the following brief account may be interesting.

Selby stands on the level surface of the great alluvial deposits through which the rivers of Yorkshire and Lincolnshire pass to the Humber. In those parts of the district which lie within the reach of the tide, the surface soil is composed of a soft fertile loam, locally termed "warp," in places many feet thick, and having its source in the sediment held in suspension in the river water. Below this, and usually forming the surface in those parts of the district above the reach of the warp, is a bed of loose yellow sand; and below this, again, is a strong brown laminated clay, in places nearly sixty feet in depth, and sometimes presenting thin intercalated beds of sand. Below the laminated clay are gravels, sands, and clays, belonging probably to the glacial period. At Escrick Station a tough brown clay is to be found, with embedded, smoothed, and ice-scratched boulders of carboniferous limestone.

Beneath all these lie the stratified deposits of red

gypseous marls and new red sandstone, which have a large extent in the vale of York and the vale of the Trent. The red marls are not seen at the surface at any points near Selby, nor indeed, as borings have shown, do they extend so far westward beneath the newer deposits; but at Holme on Spalding Moor, they are shown in a large excavation.

The Bunter sandstone lies immediately beneath the post tertiary deposits at Selby, and a few miles to the westward rises to the surface, forming two little wooded hills, called Brayton Barf and Hambleton Haugh. Westward of these, again, are the outcrops of the Permian and Carboniferous strata, and these strata no doubt extend beneath us here at Selby, although probably at an inaccessible depth.

ON THE SOUTHWARD FLOW OF SHAP GRANITE BOULDERS.

BY J. R. DAKYNS, ESQ., OF H. M. GEOLOGICAL SURVEY.

BOULDERS of Shap Granite are plentiful near Kendal. How got they there? Speaking generally, the dispersal of Lake country rocks took place radially; the ice flowed out on all sides from the Lake mountains, following very much the direction of the present water drainage. The Shap granite area is situated at the extreme south-eastern end of the Lake mountains. The greater part of this area, sloping northward, drains into Wet Sleddale, whose waters forming the river Lowther, flow north, and joining the Eden, go out to sea by the Solway. The remaining portion, facing southwards, overlooks Wastdale Beck. This beck flows north-east along the strike of the rocks to Shap Wells; here its waters turn sharp at more than a right angle, and thence flow south-south-east to join the Lune at Tebay. Had the Shap granite boulders, then, travelled south along

the present water drainage, it would have been down the gorge of the Lune, below Tebay. But they did not go down the Lune. On Mr. Goodchild's map to illustrate the glacial phenomena of the Eden Valley (*Quart. Journ. Geol. Soc.*, vol. xxxi.), the southern limit of the dispersal of Shap granite boulders on that side is drawn close to Tebay; nor have I noticed them, in the depression extending from Kendal to the river Lune, further east than Docker Garth. On the other hand, I have traced these boulders north of Kendal, directly towards the granitic area. It seems, then, that these boulders came nearly due south from the parent rock across the high ground, formed of Upper Silurian rocks, over which the old coach road goes from Shap to Kendal. The highest point where the granite occurs in place—viz., Sleddale Pike, 1,659 feet above the sea—is higher than the greater part of this ground; but the greater part of the granitic area is lower than the ground across which the boulders travelled in their southerly course. Nor is there immediately to the north of the granite any ground as high as the granitic fell itself. It is clear, then, that the dispersal of the granite boulders did not take place by means of ordinary glaciers. The boulders must either have come over the Silurian fells on floating ice, or by means of an ice sheet moving southward regardless of the shape of the ground. At first sight it seems easier to suppose that they floated over; but great difficulties stand in the way of such a supposition. The lowest part of the Silurian range, over which the boulders must have come, is the Hause. I do not know the exact height of this point; but it is between 1,300 and 1,500 feet above the sea, and is probably over 1,400. Further, an examination of the distribution of the boulders south of Kendal shows that they still continued to travel in a lineal direction nearly due south; they occupy a narrow band of country, whose long axis points directly for

the granitic area. I have not seen any west of the river Kent. The most westerly I have seen are at Hincaster. A line drawn from Sleddale Pike, the most westerly outcrop of the granite in place, to these boulders at Hincaster, bears south by west. The most easterly I have seen is on the side of Greyrigg Fell, north of Greyrigg Tarn. When the localities, where the granite boulders occur, are marked on a map, the steady lineal north and south direction of their course is very striking. Now, had the boulders floated over the Silurian Fells, the land must have been submerged at least 1,400 or 1,500 feet, and this would have produced a tolerably wide extent of water south of those fells; so that one does not see any reason why, under those circumstances, the boulders should not have been distributed far and wide, instead of being confined to a narrow band of country trending north and south. Moreover, the greater part of the granitic area itself must then have been submerged; and it is difficult to see how floating ice could pick up boulders from the bottom of the sea. An ice foot could gather boulders; but with such a submergence as one of 1,400 or 1,500 feet, there would have been but little granite left above water for an ice foot to cling to. Again, in this case, one would certainly expect that some boulders, in fact a good many, would have gone down Lonsdale. One must also bear in mind the fact, that Shap granite boulders crossed Stainmoor at an elevation of over 1,500 feet, as shown in Mr. Goodchild's map. We cannot separate the two phenomena; they bear closely upon each other. And again, in the Stainmoor case, there are very great difficulties in reconciling the phenomena with the hypothesis of floating ice, of precisely the same character as those mentioned above with reference to the southerly dispersal; so that, after all, one is driven to the ice sheet marching south under enormous pressure from behind.

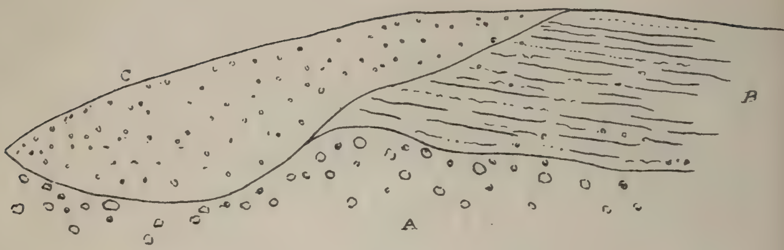


Fig. I.

A. Till.
B. Stratified Sand and Gravel.
C. Unstratified Gravel.

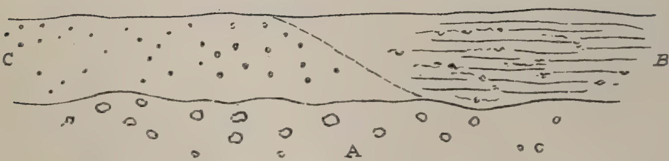


Fig. II.

A Till.
B. Stratified Gravel and Sand.
C. Unstratified Gravel.

SECTIONS IN GLACIAL DEPOSITS NEAR KENDAL.

McCorquodale & Co., Lithographers, Leeds

Most of the granite boulders near Kendal are lying on the surface; but there is one in a bank of drift cut through by the canal near Larkrigg. This shows that the boulders are not merely surface erratics, as has been stated, but that they belong to the Drift formation. Sections in this are so few and far between that we seldom have a chance of seeing erratics anywhere except on the surface. The Drift consists of two kinds—1st, Boulder Gravels; 2nd, Water-worn Gravels. The Boulder Gravels are a confused assemblage of stones, many of them scratched, of all sizes and shapes, either quite unstratified or rudely stratified. They appear either to pass into or to be mingled with the second sort. These are well stratified and water-worn gravels and sands. But by the contorted bedding and queer pockets of one kind of material in the body of a different kind, which they often exhibit, they show signs of ice floating about, or of included masses of ice melting in their midst. The two kinds are quite indistinguishable from each other, except in section; as they form externally the same character of ground.

The subjoined sections, which, though drawn from nature, I merely give as illustrations, will exhibit the general character of Drift deposits, and some of the difficulties one has to contend with in reading these records.

In Fig. 1,—A is Till; B, Stratified sand and gravel overlying A; C is Irregular or unstratified gravel, deposited in a hollow in the Till, and apparently over the denuded ends of the stratified beds. But in the next figure, Fig. 2, the section is obscure, and we have a choice between three different interpretations. First, either C bears a similar relation to A and B, as in the first figure; or secondly, it may pass gradually into B, being part and parcel thereof; or lastly, the stratified beds may be the latest deposit of all, as shown by the dotted line.

It has been well remarked by Mr. James Geikie, in his "Great Ice Age," that the Glacial Period was not one simple period of uniform conditions, but a vast protracted period of varying conditions. Accordingly, we find in one and the same locality evidences of different directions of ice flow. Thus, the Shap granite flow was from north to south; but erratics of volcanic rock from the Lake mountains are found in the neighbourhood of Kendal, east of the line of granite boulders. This indicates a flow from the north-west across the granite flow, and was probably of earlier date; for, otherwise, the lineal north and south dispersion of granite boulders would probably have been swept into confusion. Again, Farleton Fell, the conspicuous hill of bare limestone on the east of the railway between Oxenholme and Carnforth, is thickly strewn with large boulders of Carboniferous limestone, and small ones of Upper Silurian rocks, but is entirely free from either boulders of granite or of volcanic rocks. This makes me think that the boulders on Farleton Fell probably came from the north-north-west, in which direction there is a long tract of limestone; and the Silurian rocks are ten miles distant, while the nearest volcanic rocks are no less than sixteen miles off. It seems probable, too, that this dispersion took place before the limestone area was smothered in Drift, and therefore before the dispersion of the granite boulders which occur in the Drift. But this is a mere surmise. There are no scratches left to show in what direction the ice moved.

There is very little *Clay* Drift near Kendal, at least exposed in section. The Drift is all very gravelly; but near Grasmere there is an interesting section in Till. In a pit opened to get stones for road metal, by the side of the Keswick road, there are two beds of stony clay. The upper is of a greyish colour, such as any heap of stones from the surrounding rocks might be of; the lower is of a red colour,

in striking contrast to the upper. It seems odd that the two should be of such different colours, as the materials of both are derived from the neighbouring mountains. It strikes me that the following may be the cause of this marked difference. There are spaces of considerable extent among the mountains, where the rocks are stained deep red; this is due to the oxidation of iron; and I have noticed that such rocks are far more disintegrated than others. It seems as if the irony rocks were more easily acted on by the weather than the less irony. This being the case, there must have been a greater proportion of red detritus ready for removal when the ice age came on; and as the moving ice would first sweep away the weathered rocks forming the surface before it began to attack the solid unweathered rocks, we might expect that the earliest formed Drift would be of a red hue, as containing a greater proportion of red detritus than the last formed, which was derived from rocks previously unweathered.

In conclusion, I will make one remark, which seems to be called for, on weathered rocks. We read over and over again of an upper yellow, or reddish, and a lower blue boulder clay, and on this difference of colour is founded a division of a boulder clay into two distinct formations; and I know not what deductions are made therefrom. Of course there may be a boulder clay of an original yellow or red colour, as I believe the one at Grasmere to be; but in all the cases that I have seen of an upper yellow, or reddish, and a lower blue clay, the upper is merely the weathered part of the blue clay. It is the same with any blue rock. Go into any quarry of blue stone, and you will find that, while the heart of the stone is blue, the outer part is yellowish or reddish.

ON THE TRIASSIC BOULDER, PEBBLE AND CLAY BEDS AT SUTTON COLDFIELD, NEAR BIRMINGHAM. BY J. EDMUND CLARK, B.A., B.Sc., F.G.S.

THE interest to Yorkshire geologists in the various vestiges of the Glacial Epoch, scattered throughout the length and breadth of our county, awakens a corresponding sentiment as regards beds of former times, which, from similarity of appearance, we may be inclined to consider of similar origin. The rarity of such beds must be my excuse for calling your attention to some deposits, not properly included in the sphere of our labours, but lying on the borders of Warwick and Stafford. As to the true nature and origin of these, I hope that the ensuing discussion may correct or supplement what few suggestions I have here ventured to make; my main object will be merely a descriptive account of their salient features and surroundings.

Seven miles due north from Birmingham lies Sutton Park, through which a railway from Walsall, seven miles distant, running east by south past Sutton Coldfield, has been recently begun. The country is, to a large extent, wild moorland, but diversified by woods and natural and artificial water, forming a glorious field for the botanist, who may, according to the excellent monograph upon its flora by Mr. J. E. Bagnall, find nearly 600 species, besides endless varieties, within its precincts.

In company with my friend, Mr. T. H. Waller, B.A., B.Sc., the Geological Secretary of the Birmingham Naturalists' Society, I traversed, last August, the length of the railway between Sutton and Walsall. This line, as I hope to show, well discloses the relations of the Triassic, Permian, and Silurian formations, as they are locally developed.

Entering the works where the ground was being levelled for the Sutton station, we found a low cutting before us, rising eastwards, displaying ordinary Bunter Sandstone, of

a soft and friable character. I have endeavoured to obtain some local description of the rocks, but unsuccessfully. 150 yards west of a bridge to the east was a fault, of about 10 feet, the downthrow on the east; this was visible on both sides, the excavations here being about 80 feet wide. Twenty feet to the east false-bedding was very apparent, accompanied by several minor faults and a bed of marly clay. These rocks had a very slight rise towards the bridge, where they were exposed to a depth of 15 or 20 feet; the ordinary red tint prevailed nearly everywhere.

Lying upon them, to a thickness of from 5 to 10 feet at first, but reaching more than 25 feet at the bridge, was a bed of pebbles, the division between which and the subsoil —even in hollows where this reached a considerable thickness—was nowhere distinctly marked. These we thought must be recent, so closely did they resemble the numerous gravel deposits, exposed in all directions around Birmingham, which almost invariably assume the deep-red Triassic tint. The pebbles were nearly all quartzitic, a few only appearing to be of igneous origin; but these were generally much decomposed. Although coming out with ease to the hammer or pick-axe, there was more cohesiveness than is usual in recent beds, the angles in the cuttings standing out sharply.

A suspicion was thus raised as to their origin, and further strengthened when, on turning westwards, we found extensive excavations in clayey gravel beds, lying in clays, but with lenticular sand-masses very like the rock we had previously examined. This suspicion was as much grounded, however, upon their position as upon any peculiarities. In general appearance the beds corresponded strangely with the rearranged glacial gravels, so well exposed in pits on both sides of the Ouse below York. Many pebbles were of considerable dimensions, passing indeed into small boulders; on none were any ice-scratches visible.

About one quarter of a mile westwards, 200 yards or so beyond the first bridge west of the station, we found a most interesting cutting, almost entirely in the gravels, which practically determined the age of the rocks. The upper ten feet had been removed for a breadth of over 100 feet. Below this the cutting had been made to the right level, and about 18 feet broad, with vertical sides. At the beginning a branch cutting, 26 feet deep, exposed a double fault, where sands abutted on either side against pebbles, containing a horizontal wedge of sand, apparently from an inferior bed (Pl. IV., Fig. 1). This was implied, not only by the relative positions, as regards the general rule of upthrow and downthrow, but by the condition of the two beds; the thicker, although firmly cemented, not being so hard as the tongue against which they rested. This was like hard Bunter Sandstone, being 24 feet in length and 6 feet thick at the east end.

Apparently unconnected with these, and about 50 yards along the main cutting, a remarkable series of faults, bringing down what may have been the same sandbeds, was well exposed on both the north and south walls of the cutting, to a depth of 17 feet, or 27 feet below the surface (Pl. IV., Fig. 2). Our attention was first attracted by a mass of sand, let down by two faults on the south side, one striking 10° W. of N., the eastern one 42° E. of N., their dips, respectively, being 55° and 70° along the face, or about 82° and 54° in true dip. The south section was 8 feet wide, the faults meeting 9 feet down; but on the north side the sand was 27 feet wide above, and more than 9 feet below. The consistency was equal to that of the masses in the side cutting, so that we could stand and look over the sharp edge. One or both of two thin sandbeds, resembling the wedge in Fig. 2, exposed at the east end of the south section, revealed four or five minor faults, at the same inclination as the eastern one, and probably coinciding in strike. But this was uncertain, as no sandbeds made them apparent on the north side, and although there were

signs of several faults, the positions did not exactly coincide. On both sides, probably, but very plainly on the south side, they were terminated 16 feet from the thick sands by a parallel fault, which seemed to bring up the same beds as those to the west. When once discovered, a fault was easily followed, even if invisible to the eye, from the remarkable effect produced upon the pebbles. This we soon noticed ourselves, and a "ganger," passing by, asked if we could explain how it was so many of the pebbles were "burnt." Although excessively hard, where unchanged, for a few inches on either side of faults the pebbles were perfectly rotten, a slight blow breaking them to pieces, or even reducing them to powder. Was this induced by intense strain, implying the presence of enormous superincumbent deposits; or can it be accounted for simply by weathering agencies, acting along the faults? If the latter, why are not loose glacial gravels entirely reduced to this condition? If sufficient time has not elapsed, then it follows that these beds are not so recent; but if, as seems more likely, it is due to intense strain, the same conclusion is pointed to, as necessary to produce the required cause.

On proceeding, we found that this system of faults was but the first of a continuous series, extending to the very end of the cutting, which is, I believe, about half a mile long. Although the displacement varied from a few inches to a few yards, the general level of the beds changed little. This was clearly shown by a sandbed, like the thin beds already mentioned, having an average elevation of four or five feet, which it soon regained even when considerably displaced. The faults were seldom more than four or five yards apart, often much less; most ran nearly north and south, but a remarkable exception near the end, where a gravel bed ended off among sands, ran nearly east and west, the opposite section appearing many yards further on. Occasionally clay appeared among the pebbles, which invariably proved to be "burnt"

at the faults. Very rarely these were slightly open, the interspace being filled with a vein of *Calc-spar*. This is remarkable, as we did not come across Limestone pebbles. In the first number of the *Midland Naturalist*, Mr. J. Shipman speaks of Geodes of Calc-spar, very limited in number and distribution, in a Lower Keuper section at Nottingham, but considers the case unique.

The succeeding cutting displayed similar beds, but the faults were less frequent, or at any rate less obvious. This ended about one and a half miles from Sutton, and afterwards beds of soft sandstones and marls predominated, rising, slowly, the dip of 3° or 4° being easterly. The surface was now cultivated, the heath ending about the same time as the gravels ceased to preponderate. Finally, about three miles from Walsall, and four from Sutton, just east of the bridge by Aldridge, an exposure on the south side displayed marls at a much higher angle, the dip being about 30°, composed of green and red layers, very fissile. Suddenly they were followed by a bed, about 40 feet thick, composed of pebbles and boulders, some quite large, in a clayey matrix (Pl. IV., Fig. 3). This, in its turn, appeared to rest upon sand, but the strata were here very much obscured, the cutting having been finished and sloped off. Then red and grey shales seemed to alternate; but their character and age appeared uncertain, the dip being the same as at the bridge. Soon, however, the red disappeared, and a specimen of *Atrypa reticularis* made it likely that we had crossed the fault and entered upon the Silurian area. Just to the south rose the Great Barr, a well-known landmark of Lower Llandovery. More fossils appeared upon the newly-planed slopes, especially enormous numbers of Atrypa, many of them most strangely crushed. Thin beds of Limestone appear, and it is soon evident that we are on the Barr Limestone, a synonym for Wenlock Limestone, in the Wenlock shales. A little further on we entered upon a splendid section in a cutting about 30 feet deep, yielding

the *Atrypa, Strophomena depressa*, Spirifers, *Rhynconella Wilsoni, Murchisonia gracilis, Trochus*, and *Trilobites (Phacops candatus* and *Encrinurus punctata).*

Although, as will have been seen from the description, there may seem some room for doubt as to the true horizon of these pebble beds, yet the evidence, especially in the cuttings where the pebbles were interbedded among soft sandstones, seemed to point pretty conclusively to their Triassic origin. This conclusion rests further upon the unusual solidity of the beds—some of the sands exactly resembling the Bunter sections first mentioned—the remarkable series of faults, and the "burnt" condition of the quartz pebbles, wherever those occurred.

The beds, however, represented in Fig. 3, which occur just before we come upon the Wenlock shales at Aldridge, may very well be of *Permian* age. Their character was different from the previous, containing more clay and less pebbles, and the dip greater. According to Ramsay's map, the Permian is overlapped by the Bunter a very little to the south, perhaps as much as half a mile; but the frequent difficulty of fixing the exact position of the boundary between these two formations is well known.

There yet remains the very interesting question as to the *origin* of these beds, with which is involved the still more debatable point—Do such deposits bear witness to ancient periods of glacial action? About this there appears to be the greatest diversity of opinion, and I do not pretend to make an assertion where so many able investigators remain undecided. But we may profitably compare them with other similar deposits. In the same district are the red gravels around Birmingham, already noticed, and usually considered to be connected with the Glacial Epoch. The Norfolk deposits afford several very similar sections, which I examined with much interest in 1876, along the new line from Cromer to North Walsham, between Gunton and the

former town. The beds are less solidified, and flints, naturally, are less oval-shaped. Just by Gunton I noticed also a fault, bringing down an iron-stained sandbed, containing huge chalk masses, against pure sands, a fall of about six feet.

The enormous number of faults at Sutton is very striking. It will be remembered that they did not much affect the general level. Very possibly they may have originated, and so also the above, by the irregular yielding of immediately subjacent masses. Evidently it took place under enormous pressure; the edges were clean cut, and the "burnt" condition of the pebbles can hardly be accounted for otherwise.

Lastly, we have below York, the beds already referred to, very similar to parts of these deposits, and lying some height, comparatively, above the Ouse valley, well exposed by gravel pits. That these are re-arranged glacial deposits, the constituents having traversed long distances from the West Riding, Westmoreland, &c., there can be no doubt. Here and there scratched boulders may be found. The Permian layer, especially, approached these in several points, and although the Triassic deposits did not display such large boulders, and not such frequent clays, they forcibly recalled to mind our York beds. The pebbles, I understand, are probably of Welsh origin. Without making any decided statement, I will simply say that the impression left on our minds was that the difficulty of explaining their present position, without admitting the agency of ice, would be extreme.

[NOTE.—Mr. William Whitwell, of York, writes to me that, 150 yards from the line, by the boathouse on the largest lake, and therefore near the second pebble cutting, a quarry gives a section 40 feet deep of the same beds. His notes, taken on the spot in 1875, describe just the same phenomena, but "indicated some degree of deposition, at times, of similar pebbles." "The most prevalent pebble was of a coarsely crystalline, somewhat micaceous, purplish, dark grey quartzite, all perfectly smooth and free from angles—no scratches." Again, in 1876, "faint traces of stratification in fine sand-lines, and also occasional lines of larger pebbles." One of the Faults appeared almost like a "pipe" filled up with "burnt" pebbles and sand, partly in fine *lines*, "like the pebbles with a perpendicular arrangement," the sand-lines being formed of disintegrated quartzite.—J. E. C.]

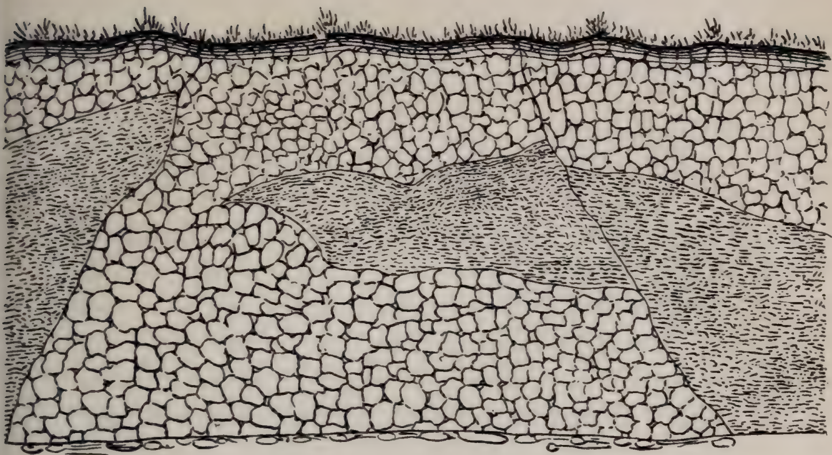


Fig. I.

E. W.

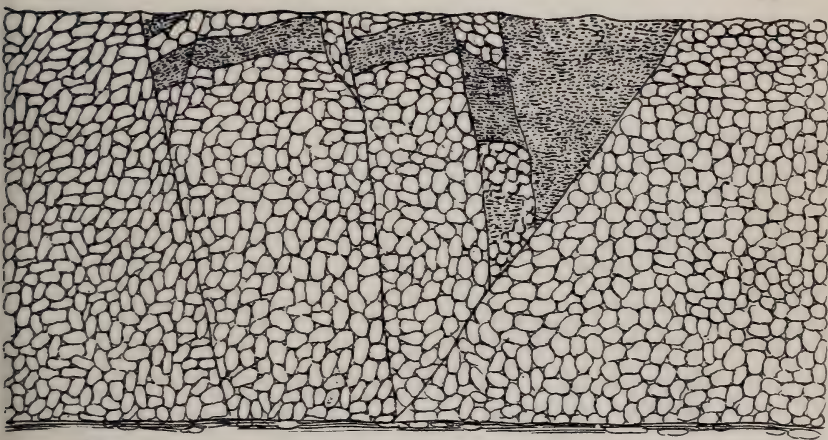


Fig. II.

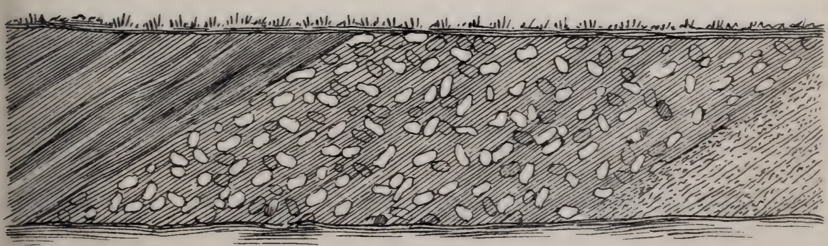


Fig. III.

SECTIONS IN BOULDER-BEDS AT SUTTON COLDFIELD.

McCorquodale & Co., Lithographers, Leeds

A CONTRIBUTION TO THE FLORA OF THE LOWER COAL MEASURES OF THE PARISH OF HALIFAX, YORKSHIRE. BY WM. CASH, F.G.S., AND THOS. HICK, B.A., B.Sc., &c.

Perhaps no branch of Palæontology presents greater difficulties to the geological student than that of Fossil Botany, and this is especially true of the fossils furnished by the Palæozoic rocks. The remains of plants are so fragmentary and disconnected, that it is very rarely that the portions of such as are found, in even tolerable abundance, can with certainty be placed in their true relations to each other; besides this, most of the fossils are simply casts or impressions, and exhibit no traces whatever of structure; added to these is the fact that those organs, such as flowers, seeds, fruits, &c., which are of the greatest classifactory importance, are the very ones which in nine hundred and ninety-nine cases in a thousand are *not* found fossilised; hence some idea may be gathered of the difficult task which lies before the botanist who attempts from these fragmentary relics of an ancient flora to reconstruct for us its long-hidden vegetable forms.

During the past ten years or so much has been done towards elucidating the structure and affinities of the plants which flourished in the Carboniferous age. In England, a fresh impulse has been given to the study of the plants of the Coal period, by the diligent and careful researches of such distinguished naturalists as Mr. Carruthers, Mr. Binney, and notably Professor Williamson, of whom we may say that he is *facile princeps*. The specimens of Carboniferous plants, so wonderfully preserved as to show structure even in its minutest details, which have enabled fossil botanists to push forward their researches much further than at one time seemed likely or even possible, have been chiefly collected (in England at least) in two localities, namely, near

Oldham in Lancashire, and in the parish of Halifax in Yorkshire. In the former place the intelligent and painstaking labours of Messrs. Aitken, Butterworth, Earnshaw, and Nield have produced a rich harvest, whilst in the latter district Messrs. Binns and Spencer have largely collected for several years. We propose in the following paper to restrict our remarks to the plants which have been collected in the Halifax district.

GEOLOGICAL POSITION.

The bed of coal in which the plant remains (having minute structure preserved) are found, is known as the "Halifax Hard Bed Coal," which lies in the lower portion of the Ganister Beds, between the Elland Flagstones and the Rough Rock or uppermost member of the Millstone Grit series.

The following is the order of superposition :—

	Ft.	In.		Ft.	In.
Elland Flagstone, - - - -	130	0	to	210	0
Shales, &c., - - - - -	50	0	,,	120	0
80 Yards Band Coal, - - -	0	6	,,	—	
80 Yards Band Rock, - - -	—		,,	20	0
Shales, &c., - - - - -	45	0	,,	120	0
48 Yards Band Coal, - - -	0	6	,,	1	2
Shales, &c., - - - - -	35	0	,,	—	
36 Yards Band Coal, - - -	0	7	,,	1	8
Fire-clay, - - - - - -	1	6	,,	4	0
36 Yards Band Rock, - - -	—		,,	15	0
Shales, &c., - - - - -	90	0	,,	100	0
Halifax Hard Bed Coal, - -	2	3	,,	—	
Fire-clay, - - - - - -	2	0	,,	6	0
Shales, &c., - - - - -	25	0	,,	30	0
Middle Band Coal, - - -	0	6	,,	0	10
Middle Band Rock, - - -	—		,,	12	0
Shales, &c., - - - - -	35	0	,,	60	0
Halifax Soft Bed Coal, - - -	1	6	,,	—	
Soft Bed Flags, - - - -	—		,,	110	0
Measures, - - - - -	30	0	,,	80	0
Shales, &c., - - - - -	0	6	,,	—	
Fire-clay, - - - - -	1	0	,,	—	
Rough Rock (Millstone Grit), -	Base.				

PHYSICAL CONDITIONS.

The fossil plant remains showing structure are in this district, so far as our knowledge and experience goes, entirely restricted to the Halifax Hard Seam. This bed consists of an earthy coal of very inferior quality, which in many parts is so thickly studded with nodules, varying in size from that of a nut to that of a man's head, or larger, as to render it unworkable. These "coal balls," as the nodules are locally called, are composed chiefly of carbonate of lime; and when broken up are found to contain stems, rootlets, and branchlets of plants, and sometimes cones, spores, and other organs of fructification are found. It is to be remarked that these nodules are not evenly distributed through the seam, but occur in large groups, whilst considerable areas are free from them. The average thickness of the "Halifax Hard Coal Bed" is about two feet. The roof consists of a thin stratum of black shale, some four inches or so thick, and this is often composed almost entirely of the flattened valves of what is accepted as a marine bivalve mollusc, the *Aviculopecten papyraceus*, Gold. Above this thin layer is a bed of shale, averaging a thickness of about five feet, and in this bed are numerous calcareous nodules, often coated over or even impregnated with iron pyrites. These are locally known as "brass lumps" and "baum pots," and when broken up are found to contain fossils, sometimes of vegetable origin, sometimes fish remains, but most commonly shells of the *marine* genera *Aviculopecten, Posidonia, Orthoceras, Goniatites, Nautilus,* &c., &c.—a characteristic shell being *Goniatites Listeri*. At the base of the coal seam is found a hard, compact fireclay, known as Ganister. It is penetrated in various directions with the roots and rootlets (Stigmaria) of the plants which once grew upon it, and whose compressed and altered remains constitute the mass of the immediately overlying coal.

CHEMICAL COMPOSITION OF THE COAL BALLS.

We have not yet subjected examples from the Coal Balls to a quantitative chemical analysis, but a qualitative examination gives the following constituents:—

Carbonate of Lime, Carbonate of Magnesia,	70 per cent.
Oxide of Iron, Sulphide of Iron, Sulphate of Soda, Sulphate of Potash, Silica,	30 per cent.

PROCESS OF FOSSILISATION.

A consideration of the conditions under which the "coal balls" are found, leads us to concur with Mr. Binney, when he says, "So far as my experience extends, the occurrence of nodules in the coal is always associated with that of fossil shells in the roof, and therefore may probably be owing to the presence of mineral matter held in solution in water, and precipitated upon, or aggregated around, certain centres in the mass of vegetable matter now forming coal, before the bituminisation of such vegetables took place. No doubt such nodules contain a fair sample of the plants of which the seams of coal in which they are found were formed; and their calcification was most probably due to the abundance of shells afterwards accumulated in the soft mud, and then decomposed, and now forming the shale overlying the coal.

At present little is known of the process by which animal and vegetable bodies are decomposed, and the particles of which they were formed removed and exactly replaced by mineral matter. All observers have been struck with the wonderful perfection of the process by which the most microscopic parts of minute vessels and cells have been

preserved in form; but no author could satisfactorily account for it, until the wonderful discoveries in *Dialysis*, by the late Professor Graham, F.R.S., showed us how crystalloids, such as carbonate of lime, could percolate through animal and vegetable membranes. It is probably by the laws of *Dialysis* that we shall be enabled to find out the process of the calcification of the specimens which occur in nodules from the Halifax Hard Seam.

LOCALITIES.

There are four pits in the Halifax district where plant remains from the Halifax Hard Seam have been collected. Two of those, Bank Top Pit and Sunny Bank Pit, are in Southowram; one at Elland, near Halifax; and the other, Sugden Pit, near Bradshaw. And here we would offer our hearty acknowledgments to our friend, Mr. James Binns, of Halifax, who has long worked hard in this field of research, and indeed has discovered most of the novelties which this district has yielded. Though one of those whose only college has been the university of Nature, and who, like Hugh Miller, has matriculated in a stone quarry, yet his fine powers of observation, trained by long and patient practical study of recent plants in the field, have enabled him to detect the analogies between fossil and existing forms; and, joined to this, he has a rare manipulative skill in preparing sections of fossil plants for the microscope (a by no means easy task), which gives promise, we trust, of still further contributions from his hands to the fossil flora of the Halifax district.

GENERA, ETC., OF PLANTS FOUND IN THE HALIFAX HARD BED.

It is no part of our purpose in the present communication to enter upon any description of the structure of the Halifax fossil coal plants, but rather to furnish a list of the forms

that have been found up to the present time. The fossils may be roughly grouped as follows:—

1. Stems, &c.
2. Organs of Fructification.
3. Undetermined Forms.
4. Fungi.

I.—STEMS.

Calamites.

Without bark, .	Bank Top Pit	Southowram.
do. .	Sunny Bank Pit	Southowram.
do.	. . . . .	Elland.
With bark, preserved, rare, ...	Sugden Pit, .	Bradshaw.

The Calamitean stems are usually decorticated. Professor Williamson mantains that the imaginary restoration of Calamites with straight stem and verticils of extremely slender twigs is a mistake, for in his Ninth Memoir on the Organisation of the Fossil Plants of the Coal Measures, we find him writing, "That such was the case with very young Calamitean stems is more than probable; but my specimens seem to show that many of the twigs of each verticil were arrested at an early stage of their development, whilst the few that were not so arrested did not differ materially in their external appearance from the branches of an ordinary Pinus."

Astromyelon.

Stems.—Sunny Bank Pit, Southowram; and Elland.

The peculiar stellate form exhibited by the pith when seen in transverse section is very characteristic. In transverse sections there is considerable resemblance between this genus and Calamites, but unlike the latter, Astromyelon had a branching unarticulated stem.

Asterophyllites.

Specimens of this genus, the central vascular axis of which in transverse section display the well-marked triangular structure with truncated angles, have been found by Mr. Binns at Bank Top Pit, Southowram.

Lepidodendron.

Two species of Lepidodendra occur in the Halifax Hard Bed—the L. Selaginoides (= Sigillaria vasculare) and the L. Harcourtii. They are both found at Bank Top Pit, Sunny Bank Pit, Sugden Pit, and at Elland.

Sigillaria.

Though fragments of this plant are common, portions of the stem, with adherent bark, being found at all the four pits already enumerated, we are not able to record as yet the occurrence of a whole stem, large or small.

Respecting the two genera, Lepidodendron and Sigillaria, Professor Williamson is of the opinion that "all the phenomena tend to confirm his previous conclusions that they belong to the same type of vegetation; that they are equally Cryptogamic plants, but that the Sigillariæ represent, so far as their vegetative organs are concerned, the highest modification to which the Lycopodiaceous type has ever attained."

(*Farularia* has been found, but we are not able to say from which pit.)

Stigmaria.

Under this name are probably confounded the roots and rootlets of more than one plant; they are found at all the pits. In studying the microscopical sections of fossil organisms from the Halifax Hard Bed, it is specially requisite to be well acquainted with the structure of these rootlets, as they are found penetrating other organisms in every conceivable direction, and are calculated to seriously mislead a superficial observer.

Lyginodendron.

The stems and bark of this genus, which rejoices in the synonyms of Dadoxylon and Dictyoxylon, has been found at Sunny Bank and Bank Top Pits, at Sugden Pit, and at Elland. The species is L. Oldhamium. In transverse section the stem exhibits a circle of plates of fibrous tissue, arranged somewhat like the Roman figures on the face of a church clock.

Diplyoxylon. Bank Top Pit and Elland.

Kaloxylon Hookeri.

A single specimen of this singular form has been found by Mr. Binns in the Halifax Hard Bed.

Fern Stems.

Professor Williamson has adopted the plan of referring the fern stems of the Coal Measures provisionally to the genus *Rachiopteris*; thus, "by adopting this plan we avoid burdening science with a number of meaningless genera, based upon characters which have little, if any, generic value, and which only possess even specific ones under peculiar limitations, such limitations arising from the variations which a single petiole exhibits according to the portion of it from which a section is made." Following this method, we have to record the following species from our locality :—

R. Oldhamia. Elland.

R. duplex.

R. Cylindrica. Elland.

(This peculiar form was first discovered by Mr. Binns.)

R. aspera.

R. (Zygopteris) Lacattii.

II.—Organs of Fructification.

Cardiocarpon. One or two examples have been found.

Lagenostoma ovoides. Elland.

Lepidostrobi of several types have been found, also detached *macrospores* and *microspores.* Of these, one form is supposed to be the fruit of plants of the Calamitean type, another is supposed to *Lepidodendroid.* Another remarkable one has been found, in which the mother cells of the spores are preserved.

Lepidostrobi and spores have been found at Sunny Bank, Bank Top, and Sugden Pits, and also at Elland.

Sporangia of Ferns.

The annulus and contained spores are in several cases wonderfully preserved.

Detached spores and spore-like bodies.

These have been found in considerable numbers, of various kinds, but have not yet been determined.

III.—Undetermined Organisms.

Oidospora anomala.

This name has been given by Professor Williamson to curious bodies discovered in the Halifax Hard Bed nodules by Mr. Binns. They may possibly be some new form of Sporocarp.

Sporocarpon tubulatum. Williamson.

These bodies of unknown affinity have been found in the nodules of the Halifax Hard Seam.

Stomata.

Professor Williamson, in his Ninth Memoir, says:—"Two fragments alone, both from the Halifax deposits, whence they were sent to me by Mr. Binns, seem to resemble objects figured by M. Grand 'Eury, "Flore Carbonifère du Department de la Loire, &c.," which belong to *Cordaites.* One of these

closely resembles the section of a leaf represented in Plate 18, fig. 1, of the work cited. The other is a fragment of epidermis, with numerous large and closely grouped *stomata*. The epidermal cells have disappeared, but the stomata are clear and distinct." We are happy to record that Mr. Binns has since discovered a very fine example of stomata, *with some of the epidermal cells preserved.*

Fungi.

We have one example of the mycelium of a fungus, which was also found by Mr. Binns.

ON AN ORTHOCERAS OF THE MILLSTONE GRIT. BY REV. J. STANLEY TUTE, B.A.

I HAVE met with an Orthoceras in a bed of black shale, immediately underlying the Cayton-Gill Beds, in the parish of Bishop Thornton, near Ripon, which presents several points of interest, apparently new. It occurs in a very fragmentary condition, associated with Posidonomya Becheri in abundance, some small fishes' teeth and scales, and a few flag-like vegetable remains.

The lower part of the fossil is about an inch and a half in length, consists of a number of meniscus-shaped portions, and tapers to a point, which is bent slightly to one side. Above this, which in the fossil is solid (Fig. 1, 2, 3 *a*), there is a hollow chamber (Fig. 1, 2, 3 *b*), the walls of which are very thin, and marked externally with parallel rings from one-sixteenth to one-tenth of an inch apart (Fig. 3 *b*). The walls of this chamber I have never yet found in a perfect state: but such portions, as I have met with, appear to show that the chamber expanded regularly until it was about an inch in width.

Fig. III.

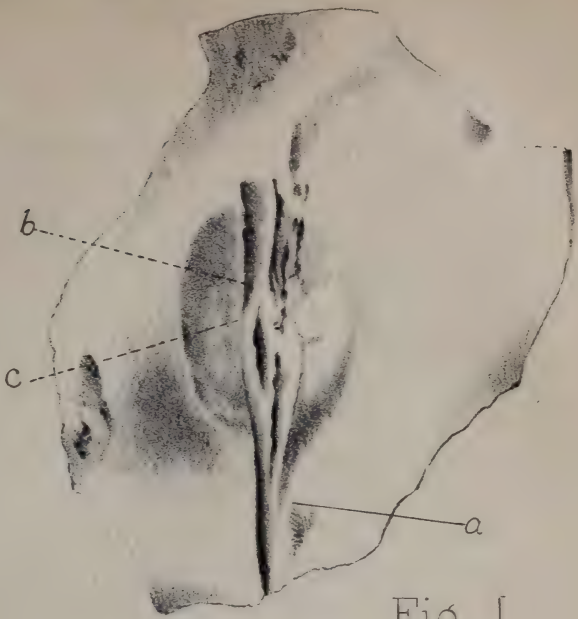


Fig. I.

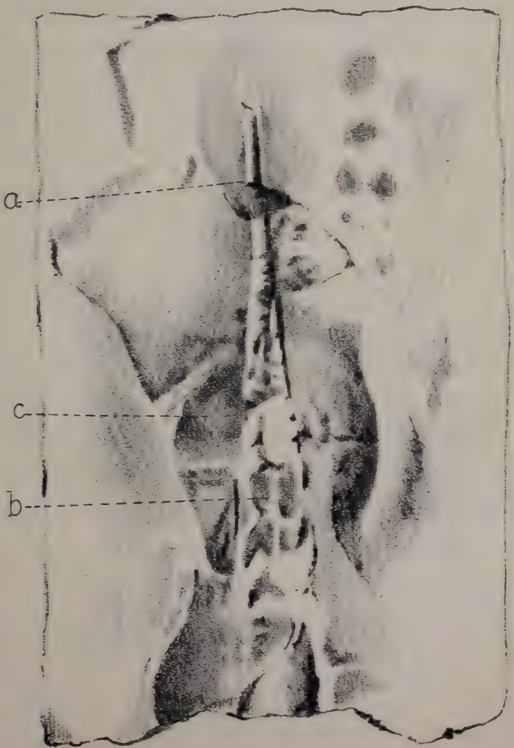


Fig. II.

ORTHOCERAS FROM THE MILLSTONE GRIT.

M'Corquodale & Co. Lithographers, Leeds

But the most interesting feature is the occurrence of two well-marked semi-oval lobes in two specimens in my possession. These lobes lie one on each side of the lower part of the wide chamber (Fig. 1, 2 *c*), and appear to me to be the fossil-marks of fins. There are, however, no other indications of structure than the form, which is well defined in its outline. The lobes also are not flat, but slightly rounded, so as to cause a distinct depression upon the shale in which the fossils lie.

If these are the fossil marks of fins, it would indicate that these shells were *internal*. The exceedingly delicate structure of the large chamber points also to the same conclusion.

The larger forms of the Orthoceratidæ are generally supposed to have been external shells; and allowing this to have been the case, it is perfectly consistent with what we know of other mollusca to believe that there were other forms of the Cephalopoda in which the shell was internal, but built up upon a plan analogous to that of external shells.

GORDALE SCAR (SEE PHOTOGRAPH). BY THE EDITOR.

The photograph issued with this volume of Proceedings represents one of the finest mural escarpments in the North of England. It is difficult to realise the terrific grandeur of the Limestone Cliffs which rise on each side the gorge; some idea may be formed, however, by noting the relative size of several of the members who may be discerned occupying various positions on the rocks near the waterfall. (The photograph was taken by Mr. Wormald, in 1877, during a visit of the Society to Malham and Gordale.) The cliffs are about 300 feet in height, in places perpendicular, but generally the upper part overhangs to some extent, the lower

having been denuded and carried away by the stream which runs through the gorge.

The whole thickness of the Scars is composed of Mountain Limestone. Its base may be seen resting on the upturned edges of sandstone and slate, which is of Silurian age. They form a part of the Great Craven Fault, which extends in an easterly direction from Ingleton, where the Mountain Limestone abuts against the Coal Measures, round the foot of Ingleborough, along the Giggleswick and Attermine Scars, behind Settle, and thence to Malham Cove. Continuing still eastwards, Gordale is passed, and the dislocation proceeds to the south of the village of Skythorne. During a great portion of this distance the dislocation amounts to a vertical displacement of nearly 2,000 feet. The whole height of Ingleborough, and at least an additional 400 or 500 feet, is required to bring the Ingleton Coal Field to its original position above the Millstone Grit, which forms the summit of the mountain. In the Malham and Gordale district, the displacement is probably less, the Millstone Grit being in juxtaposition with the Mountain Limestone; further eastwards the Fault appears to have still less influence, and its effects gradually disappear.

SECRETARY'S REPORT.

Your Committee have again pleasure in congratulating the Society on its continued prosperity and success. At the last annual meeting, held at Huddersfield, the name and sphere of operations were extended so as to embrace the whole of the county, and the style of "West Riding" was merged in the more comprehensive title of the "Yorkshire Geological and Polytechnic Society." The great addition of 48 members, or about 30 per cent. of the entire number constituting the Society, is a sufficient proof that the alteration has been appreciated.

The usefulness of the Society in spreading geological knowledge, and affording opportunity to gentlemen and students to discuss and publish the result of their investigations, in this and allied branches of science, in the North and East Ridings, it is hoped may be commensurate with the expectations expressed at our last annual meeting. During the present year meetings have been held at Selby, Scarborough, and Wakefield, and ten papers have been contributed to these meetings. Of these, four are by members not residing in the West Riding, and on subjects relating to the geology of the recently included area.

The Local Secretaries managing the affairs of the Society in various towns are now twelve in number. During the past year the following gentlemen have been appointed:—

Sowerby Bridge, . . .	Jno. Marshall, Esq.
Thirsk, ...	Ed. Gregson, Esq.
Bridlington, . . .	J. W. Lamplugh, Esq.
Huddersfield, . . .	C. P. Hobkirk, Esq., F.L.S.
Wakefield, . . .	Geo. Bailey, Esq.

Your Committee consider it very desirable that Local Secretaries should be appointed in all the principal centres of population in the county, and they will be much gratified by the receipt of suggestions which may lead to the accomplishment of this object.

Our usual annual excursion this year was given up to enable a third meeting for papers and discussion to be held. It has been suggested that a field-day, in addition to the three meetings for ordinary business, should be set apart in the coming year.

It is with great regret that we have to record the death of seven of our members, namely, Henry Brown, of Daisy Hill, Bradford; James Brown, Rossington; J. O. Carr, Barnsley; Jno. Jeffcock, Sheffield; Lord Milton; Bentley Shaw, Woodfield, Huddersfield; and Sir Titus Salt, Bart., Saltaire. Mr. Bentley Shaw was one of the oldest members of the Society, and has always taken much interest in its proceedings. Latterly, for several years, he has held the office of Local Secretary for Huddersfield. His death is recorded with much sorrow; it will be long ere the Society forgets his many acts of kindness and thoughtful care.

The Society continues to exchange Proceedings with several other learned societies at home and abroad, a list of which is appended; and these reports are always available for the use of the members of the Society.

List of Societies whose Proceedings are forwarded to the Yorkshire Geological and Polytechnic Society:—

Yorkshire Archæological and Topographical Society.
Warwickshire Natural History Society.
Royal Society of Tasmania.
Royal Dublin Society.
Royal Historical and Archæological Association of Ireland.

Geologists' Association.
Manchester Geological Society.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
U.S. Geological Survey of the Territories.
Boston Society of Natural History.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway.
Sociéte Geologique du Nord.

Copies of the Proceedings of the Society for the following years may be had on application to Mr. Crowther, the Assistant Secretary, at the Museum, Park Row, Leeds, price 2s. 6d. each:—1840, 1841, 1842, 1843, 1844-5, 1845-6, 1847, 1848, 1851, 1853, 1854-5, 1858-9, 1860, 1862, 1864-5, 1865-6, 1867, 1868, 1869, 1870, 1871, 1875, 1876, 1877.

MINUTES AND BALANCE SHEET.

Meeting of the Council at the Philosophical Hall, Leeds, February 20th, 1878.

Mr. R. Carter, C.E., in the chair. Present—Messrs. Carter, Ward, Davis, Filliter, and Atkinson.

The Hon. Secretary read the minutes of the last meeting of Council, which were adopted.

Moved by Mr. Filliter, seconded by Mr. W. Sykes Ward, and carried—"That the next meeting be held at Selby, on March 13th; that the chair be taken by Mr. H. C. Sorby, F.R.S.; and that Papers be received from Messrs. Sorby, Atkinson, Clark, and Moiser."

Moved by Mr. Atkinson, seconded by Mr. Ward, and carried—"That the following accounts be paid:—Messrs. McCorquodale & Co., £3 6s. 9d.; Mr. Alf. Parson, £6; Mrs. E. Wormald, £18 7s. 6d."

Meetings of the Society in the Public Rooms, Selby, on Wednesday, March 13th, 1878.

The first meeting was held at noon, when Mr. J. T. Atkinson, F.G.S., presided, and gave an interesting address. After a cordial vote of thanks, moved by Mr. Carter and seconded by Mr. Rowley, for the Paper, the members, under his guidance, visited and examined the Warp in process of deposition on the banks of the Ouse.

The members were next entertained at luncheon by Mr. and Mrs. Atkinson.

The second meeting was held at 3 P.M.

The chair was occupied by Mr. H. C. Sorby, F.R.S., Pres. G.S.

The Hon. Secretary read the minutes of the last ordinary meeting, held at Huddersfield, which were adopted.

Moved by the Hon. Sec., seconded by Mr. R. Carter, and carried—"That Messrs. G. Battinson, Hy. Davey, C. Fowler, W. Gregson, J. Marshall, W. C. Barber, J. Menzies, P. Sykes, J. Ward, H. Beaumont, J. W. Smithies, C. L. Mason, J. A. Heaton, J. E. Bedford, M. Fox, W. Howgate, Rev. W. J. Brookes, Messrs. W. E. Sadd, and J. Woodhead, be elected members."

Moved by Mr. J. T. Atkinson, seconded by Mr. W. Rowley, and carried—"That Messrs. J. Dunning, F. A. Bedwell, S. A. Adamson, and J. K. Blakey be elected members."

Moved by Mr. J. T. Atkinson, seconded by Mr. J. K. Blakey, and carried—"That the next meeting of the Society be at Bridlington Quay, in June."

Moved by the Hon. Secretary, seconded by Mr. John Brigg, and carried—"That the nomination of Mr. Helliwell, as Local Secretary for Brighouse, by the Council, be confirmed."

The following Papers were read:—

By Mr. J. E. Clark, B.A., B.Sc., F.G.S., "On the Triassic Gravel, Sand, and Clay Beds at Sutton Park." The Chairman, the Hon. Sec., Messrs. John Brigg and J. T. Atkinson, took part in the discussion which followed.

By the Chairman, "On a New Method of Studying the Optical Character of Minerals." The Hon. Sec., Messrs. J. Brigg, J. T. Atkinson, W. Rowley, Dr. Parsons, E. Filliter, &c., took part in the discussion.

On the motion of Dr. Parsons, seconded by Mr. John Brigg, a vote of thanks was given to the Chairman and Mr. Clark.

Meeting of the Council at the Philosophical Hall, Leeds, May 29th, 1878.

Mr. W. Sykes Ward in the chair. Present—Messrs. Davis, Ward, Tate, Filliter, Holt, Atkinson, and Dr. Parsons.

The Hon. Sec. read the minutes of the last meeting of Council, which were adopted.

Moved by Mr. Tate, seconded by Mr. Holt, and carried—"That the expenses at Selby (£2 9s. 6d.), and cost of advertisements in the *Academy*, *Nature*, &c., be paid."

Moved by Mr. Atkinson, seconded by Mr. Filliter, and carried—"That the next meeting be held at Scarborough instead of Bridlington, the date to be fixed by the Hon. Secretary when he has made the necessary arrangements."

Moved by Mr. Holt, seconded by Dr. Parsons—"That the Papers profferred by Messrs. Blake and Cole be accepted, and that the Hon. Secretary be at liberty to correspond and appoint a Chairman."

Dr. Parsons suggested that it would be useful if some field-work could be done at Scarborough.

Meeting of the Society at Scarborough, on Wednesday, July 17th, 1878.

The chair was occupied by Mr. Jno. W. Woodall, J.P.

The Hon. Sec. read the minutes of the last ordinary meeting, held at Selby, which were adopted.

Moved by the Hon. Sec., seconded by Mr. T. W. Embleton, and carried—"That the following gentlemen be elected members of the Society:—Messrs. W. Berry, A. R. Binney, J. Clegg, W. Carr, W. J. Cudworth, A. Crebbin, A. G. Cameron of H.M. Geological Survey, J. Colefax, Rev. E. Maule Cole, Messrs. A. Lupton (Prof. of Mining, Yorkshire College), J. W. Lamplugh, J. R. Mortimer, H. Müller, W. H. Newhouse, G. Scarborough, C. F. Strangeway of H.M. Geological Survey, J. Thomson, J. Villiers, and J. Whiteley."

Moved by the Hon. Sec., seconded by Mr. Stott, and carried—"That the following gentlemen be elected Local Secretaries:—For Thirsk, W. Gregson; Sowerby Bridge, J. Marshall; Bridlington Quay, J. W. Lamplugh."

The following Papers were read:—

By the Chairman, "The Physical Geography of the German Ocean."

By the Rev. E. Maule Cole, B.A., "On the Red Chalk." In the absence of the Rev. Mr. Cole, the Paper was read and specimens exhibited by Mr. Parsons.

By the Rev. J. F. Blake, M.A., F.G.S., "On the Geological History of East Yorkshire." In the

absence of the Rev. Mr. Blake, the Hon. Sec. read the Paper.

A brief discussion took place upon the Papers collectively.

A vote of thanks was passed to the authors of Papers.

Moved by the Hon. Sec., seconded by Mr. T. W. Embleton, and carried—"That Mr. J. W. Woodall be elected a member."

A vote of thanks to the Chairman, moved by Mr. Rowley, and seconded by Dr. Alexander, concluded the meeting.

Several of the members availed themselves of the use of the Chairman's yacht, and proceeded with him on a short dredging expedition.

Meeting of the Council at the Philosophical Hall, Leeds, October 16th, 1878.

Mr. W. Sykes Ward in the chair. Present—Messrs. Ward, Davis, Lister, Tate, Bailey, and Prof. Green.

The Hon. Sec. read the minutes of last meeting, which were confirmed.

Moved by Mr. Tate, seconded by Mr. Ward, and carried —"That the circular for the Wakefield meeting be adopted."

Moved by Mr. Ward, seconded by Mr. Tate, and carried —"That Professors Green and Miall, and the Hon. Secretary, be the Committee for the revision of Papers before publication."

Moved—"That Mr. George Bailey be recommended as Local Secretary for Wakefield at the annual meeting," and "that Mr. Ward be empowered to call upon Mr. H. P. Holt, asking him to act as Local Secretary for Leeds."

Moved by Mr. Tate, seconded by Mr. Lister, and carried —"That Gordale Scar be the next photograph issued to the members."

Moved by the Hon. Sec., seconded by Prof. Green, and carried—"That the following accounts be paid:— Messrs. Trubner & Co., £1 5s.; Messrs. McCorquodale & Co., £1 8s. 3d.; Mr. Ed. Wormald, £5 1s. 3d."

Annual Meeting of the Society at Wakefield, on Wednesday, October 23rd, 1878.

The chair was occupied by the Hon. LORD HOUGHTON, D.C.L., F.R.S.

The Hon. Sec. read the minutes of the last ordinary meeting, held at Scarborough, which were adopted.

The Hon. Sec. read the annual report, and the Treasurer the balance sheet, which were adopted, on the motion of the Chairman, seconded by Mr. Carter.

Moved by the Chairman, seconded by the Hon. Sec., and carried—"That the Marquis of Ripon, K.G., F.R.S., be re-elected President."

Moved by Mr. Carter, seconded by Dr. Alexander, and carried—"That the Vice-Presidents be re-elected."

Moved by Mr. Rowley, seconded by Mr. Atkinson, and carried—"That Mr. John Brigg be re-elected Treasurer."

On the motion of the Chairman, the Honorary Secretary, Mr. J. W. Davis, was re-elected unanimously.

Moved by Mr. Sladen, seconded by Mr. Laxton, and carried—"That the whole of the Committee be re-elected, and that in place of the late Mr. Bentley Shaw, Mr. Fairless Barber be elected."

The following are the Council:—

PRESIDENT.

Marquis of Ripon, K.G., F.R.S.

VICE-PRESIDENTS.

Earl Fitzwilliam,
Earl of Effingham,
Earl of Wharncliffe,
Lord Londesborough,
Lord Houghton,
Edward Akroyd, Esq., F.S.A., &c.
W. B. Denison, Esq., M.P.
Duke of Leeds,
Duke of Norfolk,
Earl of Dartmouth,
Viscount Galway,
Viscount Halifax,
Jno. Waterhouse, Esq., F.R.S.,
W. T. W. S. Stanhope, Esq., M.P.

TREASURER.

Jno. Brigg, J.P., F.G.S.

HON. SEC.

J. W. Davis, F.G.S., F.L.S.

COMMITTEE.

Dr. Alexander,
Fairless Barber, F.S.A.,
Mr. R. Carter, C.E.,
„ T. W. Embleton,
„ E. Filliter, C.E.,
Prof. A. H. Green, M.A.,
Mr. H. P. Holt, C.E.,
Prof. L. C. Miall, F.G.S.,
Mr. R. Reynolds, F.C.S.,
„ H. C. Sorby, F.R.S.,
„ T. W. Tew,
„ W. Sykes Ward, F.C.S.

Moved by Mr. Carter, seconded by the Hon. Sec., and carried—"That in our books a record be made of the great loss sustained by the Society by the death of Mr. Bentley Shaw."

Moved by the Hon. Sec., seconded by Mr. S. Seal, and carried—"That Mr. Geo. Bailey be elected a member, and that he be appointed Local Secretary for Wakefield."

The Chairman gave an address.

The following Papers were read:—

By the Rev. J. Stanley Tute, B.A., "On an Orthoceras from the Millstone Grits, near Ripon." The Hon. Sec. read this Paper in the absence of the author.

By James W. Davis, F.G.S., F.L.S., "On the Occurrence of certain Fish-remains, and the Evidence they afford of the Fresh-water origin of the Coal Measures." A discussion followed, in which Messrs. J. T. Atkinson, P. Sladen, J. Brigg, and W. Cash criticised adversely Mr. Tute's Paper. Dr. Parsons spoke on Mr. Davis' Paper.

By Wm. Cash, F.G.S., and Thos. Hick, B.A., B.Sc., "A Contribution towards the Flora in the Halifax Hard Bed Coal-seam."

By J. R. Dakyns, M.A., "Boulders near Kendal." In the absence of the author, an abstract was given by the Hon. Sec.

Moved by Mr. Carter, seconded by Mr. Sladen, and carried—"That a vote of thanks be given to Messrs. Davis, Cash, Tute, and Dakyns, for their most excellent Papers."

A vote of thanks to the Chairman, on the motion of Mr. Carter, seconded by Dr. Alexander, concluded the meeting.

Statement of Receipts and Expenditure of the Yorkshire Geological and Polytechnic Society.

FROM OCTOBER 1ST, 1877, TO SEPTEMBER 30TH, 1878.

Dr. *The Treasurer in Account with the Yorkshire Geological and Polytechnic Society.* Cr.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance	2	1	0	By Cash paid into the Bank	89	14	6
,, Subscriptions	106	0	4	,, Stationery	11	6	9
,, Beckett & Co.	48	0	0	,, Postage and Carriage	5	10	6½
,, Reports, &c., sold	1	2	8	,, Cost of Photographs	24	4	3
				,, Expenses	3	7	4
				,, Salary of Assistant Secretary (16 months)	20	0	0
				,, Balance in hand	3	0	7½
	£157	4	0		£157	4	0

Dr. *The Treasurer in Account with Beckett & Co.* Cr.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance at Bank	26	16	6	By Cash from Bank	48	0	0
,, Cash paid to Bank	89	14	6	,, Balance in Bank	69	3	7
,, Interest	0	12	7				
	£117	3	7		£117	3	7

Examined and found correct,—

October 21st, 1878. A. H. GREEN.

Summary of Geological Literature relating to Yorkshire, published during 1876 and 1877.

Compiled by James W. Davis.

1876.—ADDENDA.

Anon. [H. Woodward.] Glacial Deposits at York. *Geol. Mag.*, dec. ii., vol. iii., p. 384.

Brady, H. B. A Monograph of Carboniferous and Permian Foraminifera (the genus Fusilina excepted), pp. 116, plates i.-xii. *Pal. Soc.*

Brodie, Rev. P. B. On the further Extension of the Rhaetic or Penarth Beds in Warwickshire, Leicestershire, Nottinghamshire, Yorkshire, and Cumberland; and on the Occurrence of some supposed Remains of a new Labyrinthodont and a new Radiate therein. *Rep. Brit. Assoc.* for 1875, *Sections*, p. 64.

Butterworth, John. Coal Plants. (Ovenden Naturalist Society.) *Naturalist*, ser. 2, vol. i., No. 10, pp. 151-153.

——— Rambles after Fossil Plants. *Sci. Gossip*, No. 143, pp. 243-244; 4 cuts.

Crosskey, Rev. H. W. Third Report of the Committee appointed for the purpose of recording the Positions, Height above the Sea, Lithological Characters, Size, and Origin of the more important of the Erratic Blocks of England and Wales, reporting other matters of interest connected with the same, and taking measures for their preservation. *Rep. Brit. Assoc.* for 1875, pp. 82-91. (Information regarding Yorkshire.)

Davis, James W. On a Bone Bed in the Lower Coal Measures, with an enumeration of the Fish-remains of which it is principally composed. *Quart. Journ. Geol. Soc.*, vol. xxxii., pp. 332-340.

Evans, John. Anniversary Address. *Quart. Journ. Geol. Soc.*, vol. xxxii., pp. 53-121. (Settle Cave.)

Geological Survey Maps. (Seven sheets.) Six inches to a mile.
Sheet 233 (Rothwell.) By Prof. A. H. Green, R. Russell, and T. V. Holmes.
Sheet 234 (Castleford). By W. T. Aveline, A. H. Green, R. Russell, and T. V. Holmes.
Sheet 247 (Dewsbury). By A. H. Green. J. C. Ward, and R. Russell.
Sheet 250 (Darrington, Whitley, and Little Smeaton). By W. T. Aveline, A. H. Green, and T. V. Holmes.
Sheet 276 (Brodsworth, Barnsborough). By W. T. Aveline and Prof. A. H. Green.
Sheet 289 (Rotherham). By A. H. Green, R. Russell, and T. V. Holmes.
Sheet 294 (Sheffield). By Prof. A. H. Green and T. V. Holmes.
Sheet 219 (Kippax). By W. T. Aveline, J. C. Ward, and R. Russell.

Green, A. H. (Prof.) On the Variations in Thickness and Character of the Silkstone and Barnsley Coal Seams, in the Southern part of the Yorkshire Coal-field, and the probable manner in which these and similar changes have been produced. *Proc. Geol. Soc. W. Rid. York.*, pt. ii., pp. 68-77, pl. iv.; and *Trans. N. Engl. Inst. Eng.*, vol. xxv., p. 13.

——— Notes on the Yorkshire Coal Field. *Journ. Iron Steel Inst.*, pp. 305-317.

GREENFELL, J. G. Notes on Carboniferous Encrinites from Clifton and Lancashire. *Proc. Bristol Nat. Soc.*, n. ser., vol. i., pt. 3, pp. 476-488; plate. (Discusses Phillips' Gilbertsocrinus, and describes new species G. Koninckii, from Clitheroe.)

HOBKIRK, C. P. The alleged Submerged Forest near Holmfirth. *Naturalist*, ser. 2, vol. i., pp. 138-141.

HORIZONTAL SECTIONS of the GEOLOGICAL SURVEY. (Four sheets.) Scale, six inches to a mile.

Sheet 96. From the Northern side of the Skipton Anticlinal to the Middle of the Yorkshire Coal-field, through Draughton, Baildon, Dewsbury, to Barnsley. (Abs.) By PROF. A. H. GREEN, J. R. DAKYNS, J. LUCAS, R. RUSSELL, C. FOX STRANGEWAYS, and W. H. DALTON.

Sheet 98. Section across Millstone Grit and Coal Measure to Permian Limestone, Brimham Rocks, Great Alms Cliff, Leeds, to Sharlston and Havercroft. (Abs.) By A. H. GREEN, J. C. WARD, J. LUCAS, and R. RUSSELL.

Sheet 99. From Gybdykes, near Masham, south-west of Ripon, to Harrogate, Harewood, Roundhay, to the River Aire at Mickletown. (Abs.) By J. C. WARD, J. LUCAS, C. FOX STRANGEWAYS, and R. RUSSELL.

Sheet 100. From Boroughbridge, through Knaresborough, Garforth, and Methley, to Nostel. (Abs.) By PROF. A. H. GREEN, J. R. DAKYNS, J. C. WARD, C. FOX STRANGEWAYS, and R. RUSSELL.

HUNT, R. Mineral Statistics of the United Kingdom of Great Britain and Ireland, for the Year 1875, pp. xv.-282. 8vo., London.

JONES, PROF. T. R. On the Antiquity of Man, illustrated by the contents of Caves and the Relics of the Cave-folk. *Geol. Mag.*, dec. ii., vol. iii,, pp. 269-272. (Abs.) (Summarises the History of West Yorkshire from the preglacial age to the historic period.)

MILLER, R. On Dislocations in the Thill, with the Presence, Amount, and Tension of Gas in the Silkstone Seam of Strafford Main Colliery. *Trans. N. Engl. Inst. Eng.*, vol. xxxv., p. 23.

PARSONS, DR. H. F. The Maritime Plants and Tidal Rivers of the West Riding. *Naturalist*, ser. 2, vol. i., pp. 113-120. (Analysis by E. HUNTER of the Warp of the Humber, and list of Diatoms found therein, pp. 119-120.)

PENNING, W. H. Field Geology, with a section on Palæontology, by A. J. JUKES-BROWN, pp. x.-238.

PICKWELL, ROBERT. Geological Changes along our Eastern Shore. *Land and Water*, Sept. 30.

THORPE, PROF. T. E. A Contribution to the History of the Old Sulphur Well, Harrogate. *Phil. Mag.*, 5, ii., 50.

TIDDEMAN, R. H. The Age of Palæolithic Man. *Nature*, vol. xiv., pp. 505-506. (Victoria Cave.)

TINDALL, J. Excursion to Coxley Valley. *Naturalist*, ser. 2, vol. i., pp. 175-176.

VINE, G. R. On the Discovery of Macrospores in Carboniferous Sandstone. (Sheffield.) *Sci. Gossip*, No. 143, p. 247.

WILLIAMSON, PROF. W. C. On the Organisation of the Fossil Plants of the Coal Measures. Part vii. *Myelopteris, Psaronius, and Kaloxylon. Phil. Trans.*, vol. 166. pt. 1, pp. 1-25; pls. 1-7. (From Halifax Measures.)

——— On the Organisation of the Fossil Plants of the Coal Measures. Part viii. Ferns (continued), and Gymnospermous Stems and Seeds. *Proc. R. Soc.*, vol. xxv., pp. 68-73. (From Halifax Coal Measures.)

WOODWARD, H. B. The Geology of England and Wales: A concise Account of the Lithological Characters, Leading Fossils, and Economic Products of the Rocks, with Notes on the Physical Features of the Country, pp. xx.-476; geological map; 28 woodcuts. 8vo., London.

1877.

AVELINE, W. T., A. H. GREEN, R. RUSSELL, and T. V. HOLMES. Sheet 87. North-West of the Geological Survey Map of England and Wales.

BARROW, GEORGE. On a New Marine Bed in the Lower Oolites of East Yorkshire. *Geol. Mag.*, n. ser., dec. ii., vol. iv., p. 552.

BLAKE, REV. J. F., and W. H. HUDLESTON. On the Corallian Rocks of England. *Quart. Journ. Geol. Soc.*, vol. xxxiii., pp. 260-405. (Yorkshire Basin, pp. 315-405.)

CARTER, R. On the Mineral Aspects of the West Riding Coal Field. *Proc. Geol. and Polyt. Soc. W. Rid. York.*, n.s., pt. iii., p. 113.

DAKYNS, J. R. On Silurian Erratics in Wharfdale. *Ibid.* p. 159.

——— The supposed Glacial Origin of Carboniferous Terraces. *Geol. Mag.*, n. ser., dec. ii., vol. iv., p. 17.

——— Is there a Base to the Carboniferous Rocks in Teesdale? A Question for Silurian Geologists. *Geol. Mag.*, n. ser., dec. ii., vol. iv., p. 58.

——— On Prof. Hull's Carboniferous Classification. *Geol. Mag.*, n. ser., dec. ii., vol. iv., p. 312.

——— A Sketch of the Geology of Keighley, Skipton, and Grassington. *Geol. Mag.*, n. ser., dec. ii., vol. iv., p. 346.

——— The Antiquity of Man. *Geol. Mag.*, n. ser., dec. ii., vol. iv., p. 439.

DAVIS, J. W. On a Stratum of Shale containing Fish remains in the Lower Coal Measures. *Proc. Geol. and Polyt. Soc. W. Rid. York.*, n.s., pt. iii., p. 127.

——— On the Stems and Roots of Fossil Trees in the Lower Coal Measures at Wadsley, near Sheffield. *Ibid.* p. 179.

GREEN, PROF. A. H. On an Exceptional Occurrence of Boulder Clay near Barnsley. *Ibid.* p. 122.

HOLGATE, B. On the Minerals of the Yorkshire Coal Field as applied to the modern manufacture of Iron. *Ibid.* p. 137.

HULL, PROF. EDWARD. On the Upper Limits of the essentially Marine Beds of the Carboniferous Group of the British Isles and the adjoining Continental districts, with suggestions for a fresh classification of the Carboniferous series. *Quart. Journ. Geol. Soc.*, vol. xxxiii., pp. 613--651.

——— Premature Conclusions. (A reply to Dakyns' article, p. 312.) *Geol. Mag.*, n. ser., dec. ii., vol. iv., p. 378.

RANCE, C. E. DE. Third Report of the Committee for Investigating the Circulation of the Underground Waters in the New Red Sandstone and Permian Formations of England, and the quantity and character of the Water supplied to various Towns and Districts from these Formations, including Report on the South Lancashire Wells, by T. M. READE. *Rep. Brit. Assoc.*, 1877, p. 56. (Several references to sections, and analysis of water in Yorkshire districts.)

ROWLEY, W. On Deep Mining, and recent achievements in connection therewith. *Proc. Geol. and Polyt. Soc. W. Rid. York.*, n.s., pt. iii., p. 163.

TIDDEMAN, R. H. On the Age of the Hyæna-Bed at the Victoria Cave, Settle, and its bearing on the Antiquity of Man. *Quart. Journ. Anthropol. Inst.*, 1877.

——— Fifth Report of the Committee appointed for the purpose of assisting in the Exploration of the Settle Caves (Victoria Cave). *Rep. Brit. Assoc.*, 1877, p. 215.

TOPLEY, W., and G. A. LEBOUR. On the Intrusive Character of the Whin-sill of Northumberland. *Quart. Journ. Geol. Soc.*, vol. xxxiii., p. 406. (Describes sections in Teesdale, &c.)

WATTS, W. M. On the Physical Properties of Ice in connection with the Glacial Period. *Proc. Geol. and Polyt. Soc. W. Rid. York.*, n.s., pt. iii., p. 149.

LIST OF MEMBERS.

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Alexander, Dr., Halifax.
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Butler, J. O., Kirkstall.

Cameron, A. Grant, Stokesley, Northallerton.
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Carrington, Thomas, High Hazels, Sheffield.
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Crebbin, A., Mannville, Horton Road, Bradford.
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Durham, Machin, Thorne, near Doncaster.

Edwards, Sir Henry, Bart., Pye Nest, Halifax.
Effingham, Earl of, The Grange, Rotherham.
Embleton, T. W., The Cedars, Methley.

Farrar, James, Old Foundry, Barnsley.
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GASKELL, DANIEL, Lupset Hall, near Wakfield.
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HARRISON, H. D., Moortown.
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HELLIWELL, T. W., Brighouse.
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HOUGHTON, Lord, Fryston Hall.
HOWGATE, WM., Leeds.
HUTCHINSON, JOHN, Barnsley.

KELL, ARTHUR A., Barnsley.
KELL, GEO., Barnsley.
KNOWLES, G., Leeds Road, Bradford.

LAMPLUGH, J. W., Londesborough House, Bridlington Quay.
LANCASTER, ED., Barnsley.

Laurence, Jno., Barnsley.
Laxton, F., Rastrick, Brighouse.
Leather, J. T., Leventhorpe Hall.
Leeds, Duke of, Hornby Castle, Bedale.
Lister, Thomas, Victoria Crescent, Barnsley.
Londesborough, Lord, Grimston Park, Tadcaster.
Lowther, Sir Charles, Swillington Park, near Leeds.
Lupton, Arnold, Eldon Terrace, Leeds.
Lupton, F. M., Wellington Street, Leeds.

Mallinson' John, Blacker Colliery, Barnsley.
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*** It is requested that Members changing their residence will communicate with the Secretary.

PROCEEDINGS

OF THE

YORKSHIRE

GEOLOGICAL AND POLYTECHNIC SOCIETY.

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With Seven Plates.

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ADDRESS. By WALTER MORRISON, J.P.

The absence of our chairman, Lord Frederick Cavendish, through illness, will be keenly regretted by all of us. It has been necessary thus to find, at a moment's notice, another chairman, and the committee have accordingly asked me to take the chair to-night, and to open the proceedings with a few introductory remarks. But it is difficult for a mere amateur, whose knowledge of natural science is purely second-hand, derived from books, to say anything worth your while to listen to, on any scientific topic. I will therefore content myself with saying a word or two as to the general results of the study of the laws of nature on human society and human progress, as it strikes the mind of an outsider like myself.

The first thing which strikes us as the "differentia" of the average student of natural science is his enthusiasm and his disinterestedness. His work does not pall upon him, does not bore him; it is a hobby-horse, his happiest hours are spent upon it. Here and there you find a student of the old-fashioned subjects of education, who works for the

sake of the work; but he is the exception. The older subjects—languages, philosophy, mathematics—have got hold of the old seats of learning and of their endowments. Hence the tone which prevails not only among the scholars, but which is sedulously inculcated by their masters and tutors, is that study should be pursued for some material end. The boy is taught to work in order to get a prize, or when somewhat older, a scholarship; the undergraduate is urged to endeavour to take high honours, because that may lead to a fellowship, to the headmastership of a school, to success in professional or political life. It is seldom indeed that he is urged to work as a means to his own intellectual and moral progress, or to the enlargement of the sphere of human knowledge. Hence the manifold evils of the system of competitive examinations, so well calculated to destroy mental originality and power by driving along certain beaten tracks all minds without regard to their special aptitudes and capacities; hence the development of cramming to the exclusion of the education of the faculties. The system can be judged by its fruits. In our English universities and in our training colleges for teachers of elementary schools, we find the results of the modern system. Is it not notorious that no great book comes from the resident members of the universities? Can the English certificated teachers, all picked men, point to one illustrious name, such as adorn the rolls of the Scotch parish schoolmasters? They have been trained to spend their strength in learning just enough of a number of subjects to secure a certain class, or some similar tangible end, and, that end attained, the tools with which they have worked are thrown aside in sheer weariness, not to be taken up again but in a dilettante spirit; they become idlers through life, or if engaged in some definite work, mere machines, showing capacity only in turning out more or less faithful copies of themselves among their pupils, sometimes

too little educated to be conscious of their own intellectual and moral defects.

But we find for the most part the student of natural science humble in his estimate of his own position, devoted to his work, pursuing it from no mercenary motive, but from sheer love of it; content to labour obscurely, it may be, in some bye-way of science; content if his labours, combined with those of many others working on the same lines, can advance his favourite science in some direction, and well knowing that his labours will be appreciated, if at all, by a narrow circle of fellow-workers, that to few is it given to make brilliant discoveries. It is this spirit of humility, of self-abnegation, of searching for truth for its own sake—the spirit of the highest type of the old Greek philosophy, which makes the biographies of, and the personal converse with, men of eminence in science so attractive; it is, no doubt with many exceptions, the trait which has struck myself in what intercourse I have had with scientific men of various degrees of fame. I think, too, that among them there exists, more commonly than among other men, a real, unfeigned, generous appreciation of the work and discoveries of others.

I need not speak of the many material advantages which science has gained for man, in the production of wealth, in the improvement of communications between nation and nation, in the promotion of comfort and health. But I would say one word as to its influence on religious controversy. Looking back on the past, no cause of human suffering has perhaps been so efficacious as the disputes of men on matters of dogmatic theology. Hardly the ambition of conquerors has caused more deaths and more misery. But with the rise of the modern philosophy of the study of the laws of nature, and as a direct consequence of it, the virulence of religious controversy has abated. A religious war has become an impossibility, except between half bar-

barous nations. Men adopt the scientific methods of investigation; and, recognising the essential difficulty and obscurity of the subject, can credit their opponents with good faith. They consider more the resemblances than the distinctions of religions and sects; and we may hope that with the passing away of the old anthropomorphic notions of God, a more spiritual religion, a higher conception of and reverence for the divine nature will take their place generally among men.

There seems indeed to me no more potent factor in modern society for raising our moral and intellectual standard than the general diffusion of scientific knowledge and scientific methods among the masses.

One word more as to the English universities. I have already said that I hold them to have failed. They do nothing for the advancement of knowledge, or next to nothing. They fail to excite enthusiasm for knowledge among their students, unlike the Scotch and German universities. But their wealth is enormous, and is very rapidly increasing as leases on lives fall in. For the most part the money spent on fellowships is wasted, the "idle" fellow becomes a mere London dilettante, or uses it in apprenticing himself to some already overcrowded profession. Can no better use be found for it? Can we not endow research in some manner which will not paralyse research in the same way in which learning has been paralysed by excessive endowments? I think we can. Some small part of the wealth now wasted might be devoted to pay the cost of special investigations by approved *savans*, such as now depend on the precarious resource of voluntary subscriptions of the British Association, or the occasional aid of the Government. Some small part might be used for professorships for men who have made their mark in the world of science or scholarship, who have formed habits of steady work, and

who will not relapse into idleness on obtaining a secure position, but are likely to devote all leisure so gained to their work. It should therefore be a condition that such appointments should be open to men above the age of forty. I think it would be possible to devise a selecting body on which jobbery and canvassing would have little influence. To put a man already eminent in science above all labour and all anxiety for the satisfaction of material wants, so that he can devote his whole time to his favourite study, would be no small benefit to the world. If it were one of the conditions that he should reside at Oxford or Cambridge, it would be even a greater benefit to the university.

ON A SECTION AT THE BARROW COLLIERIES, WORSBRO'. BY ARTHUR R. KELL.

In introducing to your notice the sections of the strata sunk through in proving the Silkstone seam of coal, at the Barrow, Hoyland, and Rockingham Collieries, situate from three to four miles to the south of Barnsley, and about a mile apart from each other, I take the opportunity of thanking Mr. Arthur M. Chambers, and Mr. W. H. Peacock, Junr., for kindly furnishing me with a copy of the sinkings at the respective collieries of which they had the management, and whereby I have been enabled to lay down the three sections on one sheet, and thus the more easily point out the relative difference existing between each, as regards the depths and thicknesses of the various strata passed through. As I am more intimately connected with the Barrow Collieries belonging to the Barrow Hematite Steel Company (Limited), I shall more minutely describe the sinkings there, but shall confine myself strictly to the geological as distinguished from the engineering aspects of the same, by pointing out any similarities or differences in the three sections.

The sod for commencing the sinking of the Barrow pits was cut on the 4th of June, 1873.

Nothing worthy of notice took place until reaching the blue bind, just above the Kents thick coal, where a heavy feeder of water was met with. The seam of coal, 10 inches thick on the Hoyland section, corresponds, I think, with the Kents thick coal on the Barrow section. Several layers of dark and blue bind were passed through before reaching the next thin seam of coal, which is also found at Hoyland, although rather thinner. A throw found at a depth of 20 yards continued for 169 yards down the shaft. We have again dark and blue bind, more or less strong, and a good deal intermixed with ironstone down to the Barnsley seam, which is met with at a depth of 91 yards, but had been previously worked by S. J. Cooper, Esq.

As you will notice from the sections, I have taken the Silkstone seam as the datum line throughout, and which seam is found at a distance of 378 and 376 yards respectively below the Barnsley bed, at the Barrow and Hoyland Collieries.

Between the Barnsley seam and the Swallow Wood, met with at a depth of 151 yards, and 3 feet thick, four thin seams of coal are passed through, which are also found at Hoyland, shewing the regularity of the strata; but a short distance above the Swallow Wood, a very hard stone, 5 yards thick, was met with.

At the Rockingham Colliery, the Swallow Wood is found at a depth of 22 yards, and about 2 feet 8 inches thick. About 15 yards of rather strong material, including 6 inches of cank, was sunk through, before reaching the next seam of coal; but there is no trace of this cank at either Hoyland or Rockingham. A few yards deeper and we enter the Lidget rock, which appears to vary much in thickness, and I am happy to say, bearing in mind the difficulty of penetrating such a very hard stone, that we had only 48 feet

of it, whereas they had 63 feet at Hoyland, and 100 feet at Rockingham. Almost immediately below it we found a thin seam of coal, and which is called on the Rockingham section "Cannel Coal." From this point to the Lidget coal, the strata appears very similar to Hoyland, but at Rockingham they passed through two thin seams of coal, of which we find no trace.

The Lidget seam was met with at a depth of 221 yards, and 2 feet 10 inches thick, but rather less than the Hoyland section, the Rockingham section being still thinner. It is worked at Hoyland.

You will no doubt notice that the regularity of the strata throughout the three sections, more especially with respect to the principal seams of coal, still continues.

There was some hard material, as well as a thin seam of coal passed through before reaching the *Joan* coal, more particularly at Hoyland, where they had 54 feet of rock. From the *Joan* coal to the Flockton thick, proved at a depth of 293 yards, there is some difference in the strata of the three sections, as we do not find at Hoyland the Tankersley ironstone, which nevertheless is found to correspond at Barrow and Rockingham.

Just below the Flockton thick coal we met with a very hard rock, 24 feet thick, and which is also found at Hoyland and Rockingham. From this point the comparative regularity of the strata existing in the Hoyland and Barrow sections gradually disappears. We found the Flockton thin coal, at a depth of 323 yards, of a poor quality, and the same remark, I believe, applies to the Hoyland and Rockingham section. In the thin seam of coal found about 7 yards below the "Flockton thin" a heavy feeder of water was met with. The Fenton coal is reached at a depth of 353 yards, very much broken up, and although the aggregate quantity of coal would make a valuable seam, yet the intervening band

and spavin render it useless. Before reaching the Parkgate seam we passed through two layers of cank; but there is no trace of these at either Hoyland or Rockingham; in their place we find 10 feet of hard stone in the latter section. The Parkgate seam is found at a depth of 372 yards, of rather above an average thickness, but the quality is such as to make it not workable in the present depressed state of trade, and consequently it has been abandoned at most of the collieries in the district.

Just below the Parkgate we came across some bind, containing a quantity of ironstone, and below that again a thin seam of coal, and with this the Rockingham section agrees; but the strata at Hoyland is somewhat different. After passing through 21 feet of strong dark bind we encountered 16 feet of very hard rock, the same rock being 11 feet at Hoyland and 28 feet at Rockingham. We met with the Thorncliffe thin seam at a depth of 410 yards, being 38 yards below the Parkgate, and 4 feet thick, the Hards or upper portion of the seam being 2 feet 8 inches, and the Softs or lower portion 1 foot 4 inches. We are now working this seam.

The uniformity in the strata still continues between the Barrow and Rockingham sections, but we find that in the Hoyland section the distance between the Parkgate and the Thorncliffe is 8 yards less, being only 30 yards, but the thickness and character of the seam is very similar at all the collieries.

The work of sinking below the Thorncliffe seam progressed rapidly, as much as 12 yards being sunk in one week, the strata being of a softer nature, and after passing through four thin seams of coal, and which are likewise found in the Hoyland and Rockingham sections, the exertions of two and a half years were at length crowned with success by the Silkstone seam being won at a depth of 469 yards, on the

8th December, 1875, of an average thickness and first-rate quality. This being the first occasion of the Silkstone seam being proved below the Barnsley, and with such favourable results, caused great rejoicing to all interested in the future welfare of the district, and set at rest for ever the doubts as to whether the Silkstone seam would be found workable at so great a depth.

The importance of this fact can hardly be over-estimated, conferring, as it does, a new and lengthened life upon the South Yorkshire coal-field, which now undoubtedly contains as large and valuable a store of mineral wealth as any other coal-field in the United Kingdom; and as the Silkstone seam becomes more developed I sincerely trust and believe that the town of Barnsley, occupying, as it does, such a central position, will reap the benefit, and thereby increase its trade, wealth and population.

*** Publication of sections illustrating this paper deferred.

ON FOSSIL FUNGI FROM THE LOWER COAL MEASURES OF HALIFAX. BY WILLIAM CASH, F.G.S., AND THOMAS HICK, B.A., B.Sc. (LOND.).

In a previous communication to this Society, read at the Wakefield meeting, on October 28th, 1878, we placed on record a list of plants whose remains have been discovered in the Lower Coal Measures of the parish of Halifax. At that time the only representative in our possession of the great group of Fungi was a small fragment of the mycelium of some undetermined species, for which, as for the other specimens, we were indebted to Mr. James Binns. Since then, Mr. Binns's indefatigable industry has been rewarded by the discovery of additional examples of fossilised fungoid growths, which, though scarcely in sufficient perfection for complete identification, have many interesting characters so well preserved as to be deserving of a detailed description. The

specimens are exhibited in three microscopic slides, showing sections of carboniferous plants, cut and prepared from the "nodules" or "coal-balls" described in our former paper.

On the first slide we have a transverse section of the petiole of a fern, as well as a section, also transverse, of a portion of what appears to be a branchlet or rootlet of some other plant, but which from its fragmentary character has not yet been determined. The fungus is confined to the latter part of the preparation, but it may not be amiss to note in passing that the fern is evidently *Zygopteris Lacattii* of Renault, or, as Professor Williamson prefers to term it, *Rachiopteris Lacattii*. A single fibro-vascular bundle, composed of xylem and phloëm elements, occupies the centre of the petiole, while the remainder is made up of fundamental or ground tissue, apparently similar to that of living ferns. The phloëm was originally surrounded by the xylem completely, as is usually the case in the bundles of vascular cryptogams, but having to a large extent disappeared, its place is occupied by mineral matter. At two opposite points of the bundle the phloëm projects into the xylem for a little way, and then, branching right and left, forms a Y-shaped mass, with very divergent arms. In one of these inwardly projecting masses of phloëm, the histological elements of which are remarkably well preserved, there are several larger cells, the arrangement, position, and appearance of which strongly suggest their homology with sieve-tubes. It is, however, to the partial disappearance of the soft and delicate phloëm tissue that we wish especially to draw attention; for in this fact we seem to have an indication that the fern lay exposed to atmospheric and other adverse influences for some time, and that death and decay had already commenced before it was covered up and the process of fossilisation had set in. Extending this inference to the accompanying tissue in which the fungus is found, and we may form some idea of the

conditions and circumstances under which it was preyed upon by the parasite.

The tissue attacked bears obvious marks of the ravages which the fungus has made upon it. Its walls are corroded and less sharply defined than those of the unaffected part, so that the two can be readily distinguished, even under the lower powers of the microscope. The tissue itself may be cellular or it may be vascular. From a transverse section only it is hardly safe to speak with any degree of confidence; but we incline to the opinion that it is vascular.

The vegetative part of the fungus consists of a large number of very delicate hyphæ, which the section has cut through in almost all possible directions. The majority of these are even finer than the threads of *Penicillium glaucum*, and can scarcely be more than $\frac{1}{7000}$ inch in diameter. A few are somewhat stouter, and in these so perfectly have the structural details been preserved, it is quite possible to distinguish the protoplasmic contents from the enclosing cellulose wall. Where this occurs the protoplasm appears as a mere line occupying the centre of the thread. Branching has been freely indulged in by the hyphæ, but it is very irregular. In one respect the hyphæ differ from those of most fungi with which we are acquainted, in exhibiting at different points what appear to be a number of closely approximated constrictions, which give the filaments at these points a moniliform character. We are not sure, however, whether this may not be due to extraneous influences rather than to the nature of the fungus, though it is quite possible that the constrictions may be closely set transverse septa. Whatever be the nature of these constrictions, transverse septa are present in the hyphæ, though they can only be demonstrated with considerable difficulty. In individual hyphæ there are appearances which even in the absence of demonstrable septa would lead to the opinion that they had originally

existed. These appearances are represented in Fig. 2 (*a*), the meaning of which is suggested by a comparison with existing fungoid filaments, in which transverse partitions are normally present. In such filaments the application of a gentle heat, the abstraction of moisture, or any other influence which arrests the vital activity of the cells without destroying their organic structure, causes the protoplasm to shrink from the walls and take up a central position. In many instances the shrinking at the ends of the cells takes place at all points of the surface, and the contraction of the protoplasm is complete. But in others an intermediate stage can sometimes be recognised, in which the protoplasm remains attached along the margin of the end septa, while it contracts at the centre. In this way, the same phenomenon occurring on both sides, the septum comes to lie across a biconvex cavity, hollowed out in the protoplasm of the two cells. The appearances presented under these conditions are not dissimilar to those of some of the fossil hyphæ, save that in these last the cellulose partitions, so far as we can make out, have altogether disappeared. *Vide* Plate VI., Fig. 2 (*a*).

Reproductive Organs.—The reproductive organs are unfortunately neither abundant nor well defined. After a most careful examination of the preparation with the highest microscopic power that it will bear, we have found but few structures to which a reproductive function can be assigned with any degree of confidence. These are all of one type, and consist of small spherical bodies, the most perfect of which are shown in Fig. 1 (*b*) and Fig. 2 (*b*). They appear to have been produced at the extremities of the hyphæ, or of short branches thereof, though the one represented in Fig. 2 (*b*) is the only instance in which such a connection is actually observable. The bodies drawn are not of the same size, that of Fig. 1 being about $\frac{1}{1800}$ inch in diameter, and that of Fig. 2 $\frac{1}{1100}$ inch.

The question now arises, What are these spherical bodies, and what relation or connection have they with the process of reproduction? Three hypotheses appear to us to be possible. They may be sporangia, which, when ripe, contain endogenously formed spores, similar to those of the common *Mucor;* or they may be zygospores formed by conjugation, as in the fungoid *Zygosporeæ;* or, lastly, they may be oospores, which have resulted from the impregnation of an oogonium by an antheridium.

The first hypothesis is rendered doubtful by the fact that the bodies are found within the tissue, through which the mycelium of the fungus ramified, while the sporangia of *Mucor* and allied genera, so far as we know them, are always aerial. Still further doubt is suggested by the habitat of the fungus and the nature of the hyphæ, the *Mucorini* occurring chiefly on excreta and decaying substances, and having a mycelium composed of filaments that are normally aseptate. Between the second and third hypotheses we cannot decide with full confidence, owing to the absence of clear and unmistakable characters in the bodies themselves. Considering the probabilities of the case, however, and having regard to the whole facies of the fungus, we strongly incline to the belief that they are *oospores.*

Systematic Position.—From the above description it will be quite obvious to all who have any acquaintance with the characters by which the systematic position of Fungi are usually determined, that great difficulties are in the way of a satisfactory location of our specimen. At the same time, a review of the form and habit commonly assumed by the members of the various classes and orders of Fungi, seems to lead by a process of exclusion to the *Pyrenomycetes,* in which order the vegetative body partakes largely of the characters of our fossil form. If this be its true ordinal position, it must be referred to the sub-order *Peronosporeæ,* which

includes the much-written-of potato fungus, *Phytophthora infestans,* the common *Cystopus candidus* and other forms.

Our second slide exhibits a section that has been cut parallel to the first from the same piece of material, and is in most respects identical with it. It shows the section of the petiole of *Rachiopteris Lacattii,* together with the fungus-bearing tissue, whose appearances have been described. An examination of this slide is fully confirmatory of all that has been said with regard to the fungoid growths under description, but does not enable us to clear up doubtful points. The hyphæ are more thickly crowded, however, and are somewhat more numerous, and show very clearly the distinction between the contained protoplasm and the cellulose walls. On the nature and origin of the spherical bodies which we regard as oospores, the slide throws no additional light, save that its appearances are in no way inconsistent with that hypothesis.

The third slide is altogether different from the other two, and has been cut from material obtained from a different pit. It consists of small and disconnected fragments of vegetable tissue, which are most probably the broken *débris* of several plants. In and between these fragments are immense numbers of small round bodies, which can hardly be anything else than the spores of some fungus. Not a trace of mycelium, however, nor any other filamentous structure to which they may be related have we been able to discover. Under these circumstances it is impossible to do anything more than speculate on their probable affinities. There is, however, one group of existing fungi whose habitat closely resembles that of these spores. We allude to the *Myxomycetes,* that curious order of Zygosporeæ which, from the absence of any definite mycelium and the strange phenomena of movements etc. they exhibit, have sometimes been regarded as animals rather than plants. These forms occur commonly on old and de-

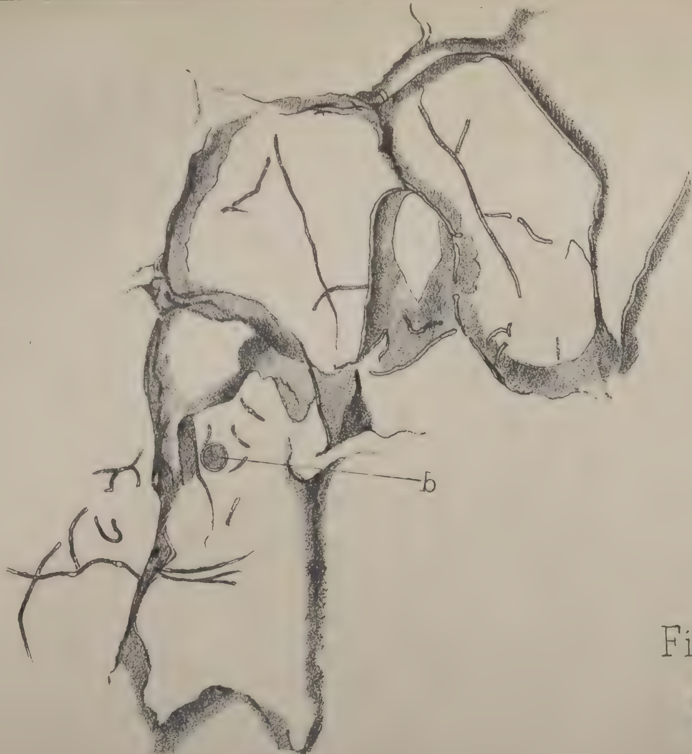


Fig: 1 × 200.

Fig : 2 × 200.

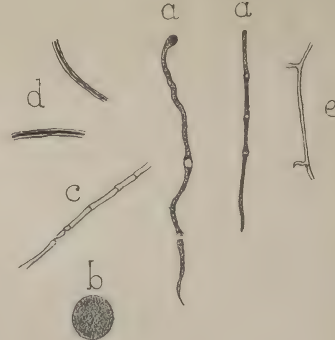


Fig: 3.

Thos. Hick, Del.

caying stumps and sticks of trees, and when in fructification consist mainly of an extremely thin-walled sporangium, filled with small spores, which may or may not be accompanied with a filamentous *Capillitium*. On the rupture of the sporangium, these spores are scattered in immense quantities, and often form a thick layer of dust on the substratum on which the fungus has grown. Now it is just possible that our fossil spores may be of a myxomycetous nature, seeing that they occur in and among tissues that have undergone a certain amount of disintegration and decay, and so far resemble those that favour the development of existing forms. Another consideration lending strength to such a supposition, is found in the fact that the size of our fossil specimens agrees almost exactly with that of spores obtained from living species, while the appearance of the two kinds is almost identical.

Description of the Plate.

Fig. 1.—Three cells of the tissue in which the fungus is found. The walls are ill-defined and evidently corroded. At *b* is one of the presumed *Oospores*, $\frac{1}{1800}$ inch in diameter.

Fig. 2.—Selected threads, showing the typical forms met with.

- (*b*) Oospore, $\frac{1}{1100}$ inch in diameter.
- (*c*) Portion of hypha showing septa.
- (*d*) Portions of hypha showing cell-wall and protoplasm.
- (*e*) Hypha branching.
- (*a*) Hyphæ suggesting the former existence of transverse septa, though now absent.

Fig. 3.—Spores, supposed to be those of some Myxomycetous Fungus.

NOTES ON TRAQUAIRIA. BY W. CASH AND THOS. HICK.

In the Halifax Hard Seam are found certain minute globular organisms, which are ornamented with branching muricated processes. These bodies were described by Mr. Carruthers, F.R.S., in 1872, who assigned to them the generic name of *Traquairia,* and concluded that their affinities were with the Radiolarian group of animals. At the British Association meeting, held at Dublin, in August, 1878, Professor W. C. Williamson, F.R.S., read a paper on these forms, in which he pointed out "that in some examples there were contained capsular membranes which were filled with cells that bore every indication of being vegetable tissues, being absolutely undistinguishable from similar cells found in the interior of macrospores, and of cryptogamic sporocarps found associated with the *Traquairia.*" The conclusion arrived at in the paper is that the organisms in question belong to the vegetable kingdom, and represent a cryptogamic form of reproductive structure. Professor Hæckel, of Jena, to whom specimens were submitted for examination, confirms the view that they are not allied to the *Radiolarians.* It has been our good fortune, through the kindness of Mr. Binns, of Halifax, to obtain two microscopic slides which throw considerable light on the nature of Traquairia, and, indeed, it is not too much to say that they conclusively attest the correctness of Professor W. C. Williamson's decision as to their vegetable affinities. As it is the intention of Professor Williamson to figure and describe the most perfect of our specimens in his forthcoming 11th memoir, "On the Organization of the Fossil Plants of the Coal Measures," we will content ourselves for the present by simply stating that the enclosure of *Traquairia* within a sporangium wall is the chief feature which renders our specimens of value as evidence in favour of the view that they are vegetable and not animal organisms.

Fig. IV.

HIGH STACK, FLAMBORO' HEAD—NORTH SIDE OF STACK.

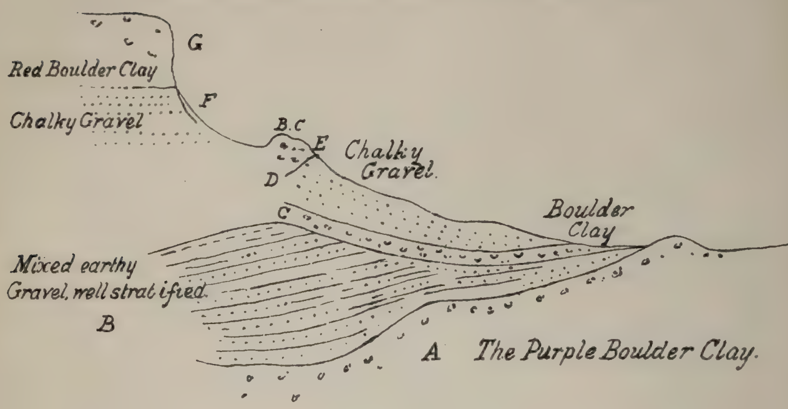
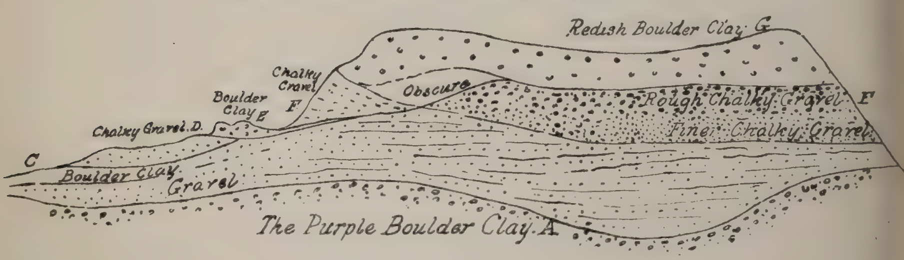


Fig. V.

HIGH STACK, FLAMBORO' HEAD—SOUTH SIDE.



G. Reddish Boulder Clay, probably the same which has elsewhere been called Hessle Clay, on denuded surface of

F. Chalky Gravel (coarse at top) on denuded edges of

B. Well stratified mixed earthy Gravel lying in a hollow in

A. The Purple Boulder Clay.

E. Small remnant of a Boulder Clay on }
D. Small remnant of a Chalky Gravel on } *Intermediate to B and F.*
C. Small remnant of a Boulder Clay. }

J. R. Dakyns, Del. M'Corquodale & Co., Lithographers, Leeds.

Fig. II.

CONTORTION IN GRAVEL OVERLYING THE "PURPLE BOULDER CLAY" IN CLIFF JUST BEYOND SECOND FENCE EAST OF SANDS LANE, BRIDLINGTON QUAY.

B.C.=Boulder Clay.

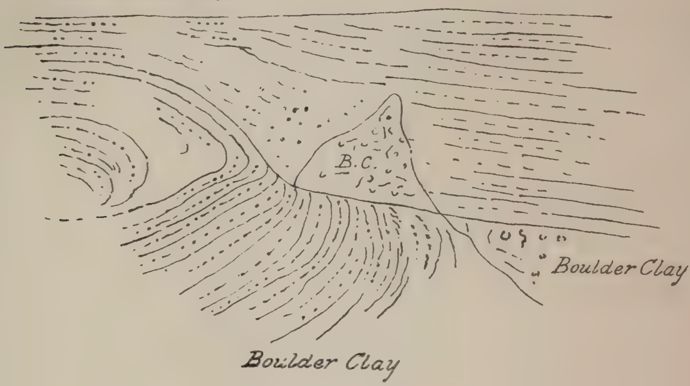
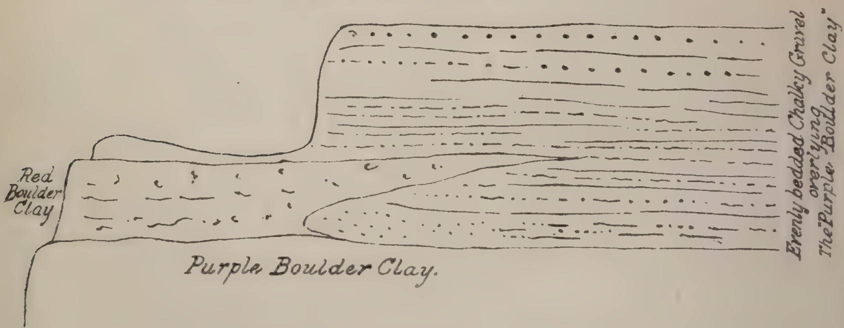


Fig. III.

SHOWING A WEDGE OF BOULDER CLAY IN THE CHALKY GRAVEL OVERLYING THE "PURPLE BOULDER CLAY" AT THE SECOND FENCE SOUTH OF SEWERBY PARK.



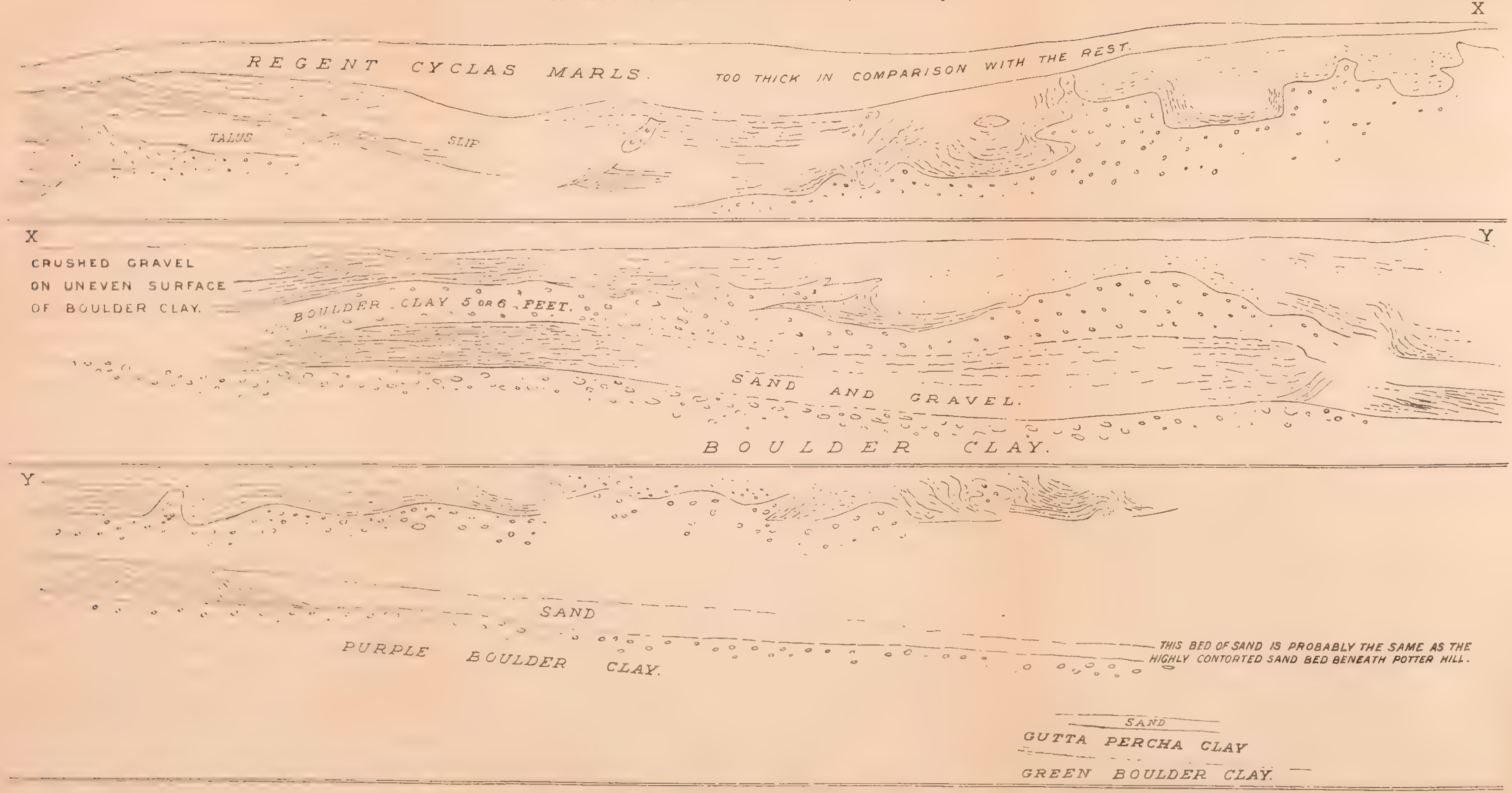
NOTE.—*The Red Boulder Clay is probably the same as that which has been elsewhere described as Hessle Clay.*

J. R. Dakyns, Del.

M'Corquodale & Co., Lithographers, Leeds.

Fig. I.

Diagrams of Cliff Section south of Sands Lane, Bridlington Quay.



J. R. Dakyns, Del.

M'Corquodale & Co., Lithographers, Leeds.

GLACIAL BEDS AT BRIDLINGTON. BY J. R. DAKYNS, M.A., OF H.M. GEOLOGICAL SURVEY.

THE chief deposit of Holderness, as is well known, is a great mass of Boulder Clay or Till, with interbeds of sand, gravel, etc.

At Bridlington Quay this Boulder Clay is immediately overlaid by a set of beds, consisting of sand, gravel, and warp. What is the precise relation of this set of beds to the glacial deposits as a whole?

Immediately north of the town, for the distance of about half-a-mile, the cliff is low, being perhaps thirty feet above mean tide level. Along this portion of the cliff, the gravels immediately overlying the boulder clay are crushed and contorted in the strangest fashion, and contain included masses of boulder clay, and tongues of boulder clay intruded into their midst, as shown in the diagram. The surface of the boulder clay is very irregular after a fashion that cannot be due to mere aqueous erosion. Wherever there is a vertical wall of boulder clay the gravel beds are vertical too, the pebbles having their longer axes vertical; and where there is an intruded tongue of boulder clay, the beds of gravel are bent round conformably to the shape of the intruded mass, while at other times all traces of bedding is lost in the general smash.

It is obvious that, after the deposition of the gravels in regular layers, or perhaps in some cases during their deposition, some force, doubtless that caused by moving masses of ice, has crushed the till and gravels together.

These gravels, then, are clearly of glacial age, though posterior to the great mass of boulder clay.

It is as well, before going further, to note the fact that the gravels above described consist to a large extent of chalk pebbles.

At Potter Hill the cliff rises to over fifty feet above mean tide level, and continues to rise by steps to Sewerby Park. Along this part of the cliff the gravels immediately overlying the boulder clay are similar in lithological character to those last described; but exhibit a striking contrast in this, that they are as a rule evenly bedded, and free from contortions or intrusions of boulder clay. A very thin seam of gravel along the slope of Potter Hill connects the two sets. One could wish it were thicker; for the suspicion will cross the mind that it may be merely a wash down the hill side of the gravel forming the hill top. It appears however to be a *bona-fide* deposit of gravel in place.

These evenly-bedded gravels I call, for the sake of distinction, the Sewerby gravels. Their general undisturbed character, in such striking contrast to the crushed gravels not a stone's throw off, makes one hesitate whether to consider them as of glacial age or not. Constant search of the cliff, however, during the winter storms, at last revealed a spot where these gravels too show a decided contortion in their lower part. (See figure.) This is near the second fence east of Sands Lane. And again at the second fence, south of Sewerby Park, these gravels contain a wedge of boulder clay of a reddish hue near their base. If then we take the Sewerby gravels as a whole, we must allow that they date back to the glacial period; that their deposition commenced at all events before that of boulder clay had ceased in these parts; and these gravels have hitherto been treated as a whole, though assigned to a post-glacial date. It may be however that we really have in these cases two gravels of very different age in immediate juxtaposition. There are places along Sewerby Park where there certainly are two gravels, the upper one chalky, and lying flat over a lower one consisting mainly of drift pebbles and undulating; but as we come south from this locality, this distinction ceases to be

traceable; so that it seems best, at all events provisionally, to take the Sewerby gravel as *one*, the lower part of which is of decidedly glacial, though it may be late glacial, age; while the upper part may or may not be post-glacial. Into the interesting question of the precise relation existing between the crushed and the evenly-bedded gravels, I cannot enter now. On the south side of the town there is a cliff corresponding to that on the north side; and the shape of the ground suggests that the two were once continuous before the erosion of the valley in which the town stands. The section on the south is as follows:—at the top very chalky gravel resting on an eroded surface of sand, but at one spot dovetailing therewith; below the sand (speaking generally), beds of finely-laminated sandy clay (Phillips' warp); and below the warp, gravel not continuous, but lying in hollows of the boulder clay, which forms the base of the cliff. The bottom gravel has in places a rather glacial look; and near Apple Pie Cottage, where the greater portion of the beds forming the cliff have been denuded and replaced by recent lacustrine and fluviatile deposits, the small portion left of the older beds, consisting of gravel and sand, partly abuts against a wall of boulder clay and partly is overlaid by boulder clay.

Amongst the overlying beds of warp, sand, and gravel, there are few, if any, undoubted signs of glacial action. At one spot, however, in the midst of the beds of fine sand, and warp, a large boulder is lying imbedded; at another spot the laminæ of the warp are contorted or crumpled.

The warp passes into sand and gravel, or thins out northward, so that it does not reach to the site of the town.

The most remarkable thing in the south cliff is a band of convolutions in the sand above the warp. These seem to occur only along one horizon. They are for the most part exactly like concretions in sandstone; some few of them

are not so, but the greater part I believe to be simply incipient concretions. The chalky gravel overlying the whole comes on about half-a-mile south of Clough Bridge, over the Gipsey. It generally lies on an eroded surface of sand; but at one spot most distinctly dovetails with the sand. This shews that it is of the same general age as the underlying beds; and that the eroded surface of these was caused by contemporaneous denudations.

Too much importance has been attached to such cases of partial unconformity, as if a great difference of age in the over and underlying beds were thereby necessarily implied. Geologists from the West Riding, who have paid much attention to the rocks of the neighbourhood, must be acquainted with scores of cases where such instances of contemporary erosion occur among the carboniferous rocks; but no one dreams of taking such for anything more than local variations, or expects to found universal divisions upon them. Amongst the glacial beds of Holderness, however, it seems to be thought that such cases imply great divisions, and must be of far-reaching extent. In fact, both too much and too little importance has been attached to divisions in the boulder clay series: too much in so far as certain divisions have been seized upon and made to mean enormous differences of age; too little in that other divisions of perhaps equal importance have been entirely neglected. Thus many writers have recognised three boulder clays, whereas in some places there are four divisions in one of their boulder clays, with a like number of unconformities, or of changed conditions, or of both, as for instance at Dane's Dike, and the High Stacks at Flamborough Head.

Some writers, again, speak as if there was but one *real* boulder clay, THE boulder clay, one and indivisible; and all other stony clays were mere *remanié* beds. The great purple boulder clay itself, with its scratched, and

polished stones, has been set down as no true boulder clay, but a mere mass of stuff washed out of *the* boulder clay. And as part of the story, a portentous number of black arrows, pointing now up, now down, are introduced to indicate so many upheavals and depressions of the land. One might fancy we had to do with cases like that lately figured by the Society in their photograph of Ribblesdale, where massive beds of mountain limestone are seen lying nearly flat on the upturned and denuded edges of Old Silurian Slates. Whereas the truth is that in the glacial beds, unconformities (so called) and eroded surfaces, instead of indicating great breaks in the series, are, in nine cases out of ten, merely local and contemporaneous. Erosion was the order of the day. Each new extrusion of the ice-sheet ploughed out a portion of the previously deposited beds, and the hollow was anon filled in with a fresh deposit, whether of current-borne sands and clays or of ice-borne till. But it is all one great boulder clay formation. Of course there are wide-spread divisions, implying great lapse of time, and great changes of condition; such as the two boulder clays (very distinct in character) of Lancashire, with the far-reaching "middle sands" between them. But it is not every wretched patch of gravel, or every eroded surface of a till that has this meaning.

Again, too much faith is apt to be placed in lithological differences as indicating differences of age, as if one and the same bed of till would not necessarily have different sets of stones embedded in it in different parts of its extent. Lastly, the same may be said about colour as a test of age. There are cases where colour is an invaluable test, as in some of the Thanet beds, and in the tea-green shale of the Rhœtics; but before colour can be safely so used (save quite locally), it must be *proved,* not assumed, to be a characteristic mark; and if all colours do take among

blue rocks, like these boulder clays, as a means of identifying beds far apart, red is about the most delusive: as all blue rocks are apt to turn red by chemical action, save when under some considerable cover; and thus the upper parts of blue rocks, where they come to the surface, are more likely than not to assume a red hue. I think that to some observers the warning is needed that the Latin poet gave to the handsome lad—"*nimium ne crede colori.*"

NOTE.—It is as well to state that the Purple Boulder Clay of Holderness is in many places *distinctly stratified.*

ON THE ORIGIN AND FORMATION OF THE WOLD DALES.

BY REV. E. MAULE COLE, M.A., ETC.

IN a paper on the Red Chalk, which I had the honour to address to your Society last year, I said, with reference to the surface configuration of the Wolds, that the rim or highest portion of the basin of the chalk area was now thinnest "owing to *subaerial* denudation."

These latter words have been objected to by a friendly critic, who says that I ought to have written "owing to *submarine* denudation."

This criticism opens at once the floodgates of controversy. Different men, equally distinguished as geologists, hold different opinions on the subject of denudation.

Let me first explain my meaning in the quotation alluded to. All that I meant to assert was, that *after* the final emergence of the chalk area of the East Riding above the sea level, that portion of it which constitutes the high Wolds was exposed to subaerial denudation, and therefore reduced in thickness and made so far thinner in comparison with the other portion, which is protected from atmospheric influences by the Boulder Clay of Holderness (see Appendix A). I did *not* mean that in the process of elevation no other causes

had tended to produce the thinness of the rim itself, which is only 200 feet on the highest ground, as compared with 800 feet below the clays of Holderness (see Appendix B). Nor did I intend to convey the impression that the present configuration of the Wolds, with its remarkable ramification of deep sinuous dales, was owing solely to subaerial denudation.

This leads me to the subject of my present paper, "The Origin and Formation of the Wold Dales."

Let me first direct your attention to a sketch plan of a portion of the Wolds surrounding Wetwang, contained within the limits of a single water basin, taken from the Ordnance map (map A), Plate x.

As a surface picture, it presents at first sight an exact copy of a mud flat abandoned by the receding tide, or of a river in an alluvial plain fed by innumerable tributaries.* But it is not so in reality. One glance at the actual features of the country will dispel the notion. No *running water* ever did, or could, in this particular area, scoop out the dales with which we have to deal; and as a matter of fact, chalk is not mud, and no amount of *tidal* action could produce the peculiar features of the East Riding dales.

Doubtless both these statements will be challenged. The first in fact has been already met by Messrs. Jukes and Geikie,† who assert that "the absence of running streams on the surface of the coombs and valleys of the chalk countries is no proof of the non-existence of these streams, but only of their subterranean character." If by this it is implied that the dales have been excavated by running water, only subterranean, instead of superficial, I venture to affirm that there is no ground whatever for the assertion. The way in which water is contained in the porous chalk at different levels of saturation (see Appendix D), the fact that the effect of

* See Appendix C, with Maps B and C.

† *Manual of Geology*, 3rd Edit., p. 458.

rainfall on the Wolds is rather to fill up existing valleys, by carrying down the steep sides a certain amount of loose material, and leaving a talus at the bottom, added to other reasons which will appear in the sequel, entirely preclude the idea.

It will be well however at starting, to add somewhat, by way of description, to the sketch map, which only presents to the eye the connection and ramification of the dales in the area selected.

The dales have a uniformly level surface at the bottom, varying from a few yards to upwards of 100 yards. The bottoms are mostly composed of a cherty gravel, which increases in thickness as the dale approaches the sea level; but in some, and notably in Thixendale, the bottom consists purely of [Kimmeridge] clay; the chalk having been cut through to its base. The sides are truly sinuous, and correspond in this respect—that wherever one side is concave the other is convex: but as a rule, and as might be expected under any theory of excavation, the concave side is the steepest.

The steepness varies considerably, from 10 degrees to nearly 40 degrees. The opposite sides are in many instances of the same elevation, and rise at the same angle; but it frequently happens that where one side rises abruptly the other has such a long gentle slope that the features of a true dale are almost lost. As a rule the steepest sides face the north and west. This is well exemplified in the dale leading from Burdale to Thixendale, round to Wayrham; also in Yorkdale, leading from Fimber Station to Sledmere.

The depth also varies considerably, from 30 feet up to 200 feet. The level of the bottom rises by a gentle slope upwards for a distance of some miles, but increases rapidly towards the termination as it reaches the tableland.

On the sides, and at varying elevations above the bottom, are found here and there beaches, or beds of gravel, composed

of comminuted fragments of chalk and flint, which appear, both in nature and deposition, different from the cherty gravels of the bottoms (see Appendix E). In some cases, as at Fimber (Cole Nab) and Burdale, they extend upwards, from the dale bottom to the top, 100 feet; in others, as at Huggate (Holm Dale), they are found fringing the top only, at an elevation of more than 100 feet above the dale bottom, and 600 feet above the sea level; and occasionally, as at Fridaythorpe, they are met with on the tableland itself, apart from any dale. These facts moreover are to be noticed, that, as a rule, these gravel beaches face the north, that they are most frequent at the junction of two dales, and that they consist entirely of local matter.

1. *When and how were they deposited?* And

2. *What effect has subaerial denudation had upon them?*

An answer to these questions will, it is believed, serve to throw some light upon the origin and formation of the dales.

1. They must have been deposited either by marine currents or by glacial agency. From this alternative there seems no escape. I cannot admit that they are "rain-wash." This idea is negatived by their position. But *when* were they deposited? Bearing in mind the well-ascertained facts that, during the glacial epoch, the land was submerged to a depth of upwards of 1,000 feet, and subsequently re-elevated to a somewhat higher level than that of the present outline, with probably minor oscillations between, it is impossible to suppose that the present gravel beaches date back to a point of time *previous* to the last emergence. They are the remnants of the last agency,* whether glacial or marine, and nothing else has touched them since but subaerial denudation.

* Page, *Geology for General Readers*, 3rd Edit., p. 238.

2. Then what has subaerial denudation done to them during the tens of thousands of years which have elapsed since the glacial period? Of course, to some extent, they have participated in the general lowering of the surface by the *chemical* action of rain-water, which dissolves so many grains per annum of lime (see Appendix F, with tables); but, as to the *mechanical* action of rain and other subaerial agencies, there is nothing to show for it in all this long sequence of years but a little talus which has, here and there, been washed down and spread over the level surface below, and the little couloir down which it rolled.

Now the valleys must have been formed, and probably have attained their present contour, *before* the beaches were deposited, which rest upon their sides.

We gather then two or three important results: (1) That the effect of subaerial denudation in the erosion of the dales, since the glacial epoch, has been approximately *nil*; (2) that the valleys must have existed before the last emergence, *a fortiori* before the last submergence, for the sea is confessedly a leveller, not an excavator; and (3) that the present valleys were affected as much as the present tableland, and in all probability far more, by the great mantle of ice which, in the glacial epoch, pressed upon hill and dale with unknown but immense thickness, as it does upon Greenland now.*

Hence we may safely conclude that the dales are the paths by which the then glaciers ploughed their way to the sea, or rather to the great central glacier which filled up the North Sea. The sinuous windings, the deep indentations, the beautifully regular, steep, and curved outlines,† the level gently sloping bottoms, added to the fact that the *débris* of the upper dales has been removed, and deposited at a lower level of several hundred feet, all point to this agency as a grand feature of their formation.

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* Jukes and Geikie, p. 703. † *Ibid.*, p. 702.

It must not, however, be overlooked that, though ice stamped its mark upon existing depressions, so as to enlarge, deepen, and curve them, and to fix, as it were, the present formation, ice did not *initiate the depressions.* They were there before.

We have not yet reached the *origin* of the dales, though we have learnt something as to their *formation.* Nor have we quite exhausted this latter subject: we have not taken into sufficient account *marine* action.

It is fair to presume that, as a sheet of almost continental ice covered the whole of the north of England at the glacial epoch, the land as it sank, during the subsequent submergence, was little affected, if at all, by the action of the sea; land and ice went down together. But on its re-emergence, though still in Arctic conditions, waves and currents, with floating ice, must have exercised some influence on the land-locked fjords of the Yorkshire Wolds. It is to this period that I assign the formation of the beaches already alluded to.

To come back, however, to the *origin* of the dales, the depressions, whether shallow or moderately deep, were undoubtedly in the line of the present valleys *before* the glacial epoch set in.

What was their origin?

Before we can answer this question in any degree satisfactorily, we must go back throughout and beyond all Tertiary times to the deposition of the chalk itself.

Chalk was confessedly deposited in at least a moderately deep sea. That portion of its area with which we are now specially concerned was deposited on an ancient [anticlinal] denuded axis, as is proved by the fact that the chalk at Wharram, Wharram Percy, Burdale, and Thixendale, rests on Kimmeridge or Speeton clay, whereas within a few miles distant, as at Huggate, Millington, and Warter, it rests on

Lias. A previous axis of elevation is wont to repeat itself. Hence we are not surprised to find that the highest elevation of the chalk wolds follows the previous axis of elevation from Garrowby Hill to Flamborough. But coincidently with this is another elevation, almost at right angles, from Garrowby to the Humber, and beyond, to Lincolnshire.

It follows from this that the intervening portions in the angle must have been more or less compressed, and so have produced inequalities of surface during the process of elevation, as is shown by the fact that the beds of chalk in this area repeatedly dip in different directions, or are tilted, though the general dip of the mass is towards the south-east.

It must be noticed also that the very fact of the elevation of beds, deposited in a fairly deep sea, to the height of nearly 1,000 feet above the sea level, must have produced a tension in the upper beds, independently of any angle, determining in many cases the lines of erosion.

Subaerial agencies, aided by submarine during the process of primary elevation, stamped a permanent feature on these inequalities, which were not obliterated, but rather increased, during the long ages in which, previous to the glacial epoch, the chalk wolds were first islands, then a portion of the dry land of England, and perhaps of the continent of Europe.

Ice subsequently stepped in and moulded the peculiar features which we see at the present day.

The foregoing remarks are a brief summary of the opinion which I venture to suggest as to the origin and formation of the dales, and a few notes and illustrations are thrown into the form of appendices, so as to leave more time for discussion, if desired.

Appendix A.

The question resolves itself into this—given two beds of chalk, one raised nearly 1,000 feet above the sea level, and exposed to atmospheric influences, the other lying below the sea level, though not under the sea, and completely covered up by a thick deposit of clay: which will wear away fastest? There can be but one answer to this question, which it is needless to repeat. It must also be remembered that the disintegration of chalk by subaerial agency is carried on almost entirely by *chemical* action, not by *mechanical.* The quantity of chalk removed and carried off by springs in the form of *hard* water, *i.e.*, water impregnated more or less with carbonate of lime (removal or transportation is a necessary element of denudation), is due to the presence of carbonic acid introduced by rain. Water can only absorb a certain proportion of carbonate of lime, then it ceases to act as a *chemical* agent.

Hence, though the chalk is completely saturated with water in the lower beds (not geologically lower, but lower in altitude, as in Holderness), the chemically-denuding action of the rainfall is chiefly confined to the upper beds, *i.e.*, to that portion of the chalk which is immediately exposed to the atmosphere.

[*Further remarks will be found under Appendix F.*]

Appendix B.

It stands to reason that, in the process of elevation of any area of the earth's surface, waves and currents must exert a far greater influence on the slowly emerging portions than on those still buried in the depths of the sea. Even the highest points of the Wolds were once islands, exposed to waves, winds, and storms on the sides where now the smiling vales of York and Pickering lie basking at their feet; and it is precisely in these directions, west and north,* that the chalk ridges have been most attacked and worn into steep declivities, as at Acklam Brow and above Kirby Underdale, or else gradually thinned down, as at Grimston Brow, because then, as now, the fiercest gales came from those quarters. From these operations the chalk of Holderness would be protected by its then submarine position and mantle of clay.

* Page—*Geology, Advanced Text Book,* 2nd Edit., p. 293.

Appendix C.

"Mud banks left by the retiring tide imitate in miniature a country with hill and dale."—*Darwin.*

"The repeated drainage action of the falling tide finds its analogue on the land in the drainage action of the falling rain."—*Jukes and Geikie.*

"So close is the similarity of a system of drainage established in this way to what is found in a large *river* basin, that those who have thought most upon the subject believe that one may be taken to explain the other."—*Huxley.*

It seems presumptuous to differ from so high authorities as to the conclusion drawn; yet, if I have stated the case fairly in the three quotations above given, I confess that I have grave doubts on the subject, so far as regards the chalk area, where there are neither running streams on the surface of the valleys nor any subterranean, as far as can be ascertained, in the same lines.

Speaking of the Wold dales, Professor Phillips writes: "Where several of these valleys meet they produce a very pleasing combination of salient and retiring slopes, which resemble, on a grand scale, the petty concavities and projections in the actual channel of a river. No doubt these valleys were excavated by water, but *not by the water of rains, or springs, or rivulets.*"

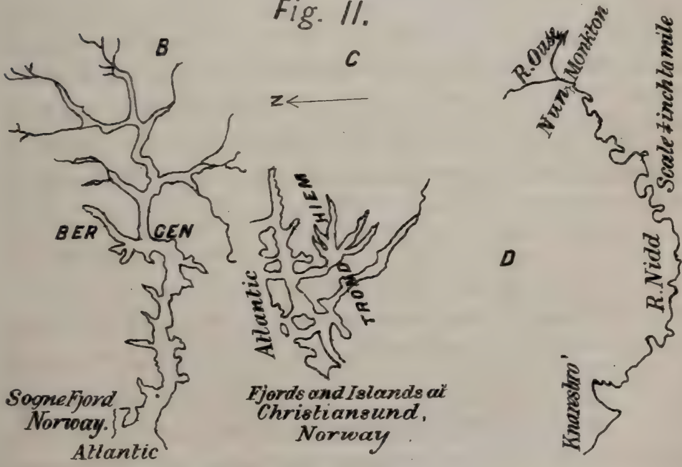
It may be interesting to compare with the sketch, Plan A, two tracings of Norway fjords (B and C), and one of the river Nidd (D), in the Vale of York.

The two former present several points of similarity to the Wold dales, not only as seen in the map, but in reality. The fjords are long (as much as 120 miles), sinuous, branching inlets, occupied now by the sea, with steep, precipitous sides, and a level bottom beyond the sea level, and terminate rapidly and abruptly at the inner extremity. Their sides are far steeper than those of the chalk dales, probably from the difference of material; and they also differ in having waterfalls and streams at work on the margins. They must have been largely eroded by glaciers, and ice action is visible everywhere. If the theory of the excavation of rockbasins by ice, as held by Professor Ramsay, is true, it may be that their great depth, as compared with the sea outside, is due to this cause. Others hold that they are depressed land valleys that the North Sea is rapidly filling up, but that the *dēbris* has not penetrated beyond the bar at their mouth. Anyhow, from the existence of sea beaches and shells at a higher level than the tops of the fjords, it is certain that, like the dales, they have been subjected at some time to the direct action of the sea; and, from other proofs, that, like the dales, they have been moulded by the grinding action of glaciers. These two

Fig. I.

A.	*Acklam Brow.*	*B.*	*Burdale.*
C.	*Cowlam.*	*S.*	*Sledmere.*
D.	*Driffield.*	*T.*	*Thixendale.*
F.	*Fimber.*	*W.*	*Wetwang.*
Fy.	*Fridaythorpe.*	*Wa.*	*Wayrham.*
H.	*Huggate.*	*G.*	*.Garton Slack.*

Fig. II.



E. M. Cole, Del.

M'Corquodale & Co., Lithographers, Leeds.

causes have probably contributed most to their present formation, whilst, for their origin, we must go back to the time when elevation first caused inequalities of surface by tension or compression.

In the other diagram (D) the remarkable windings of the river Nidd illustrate well the propensity of running water to produce sinuous curves, but it does not appear that the river has had anything to do with excavating the Vale of York. It has simply confined itself to the work of excavating its own channel, and transporting a certain amount of sediment brought into it by the rainfall. Where there is no river or running water, as in the Wold dales, it is impossible to conceive either the excavation of valleys from this cause, or the removal by transportation of the large amount of chalk rubble, which constitutes the bulk of the bottom gravels.

Appendix D.

In connection with this subject I would refer you to an interesting paper published by the Institution of Civil Engineers (No. 1,554, Vol. lv., session 1878-79, part 1), on the Chalk Water Supply of Yorkshire, by my friend, Mr. J. R. Mortimer. Few men can speak with so much weight and authority on the geological and hydrographical features of the chalk area of the Wolds as Mr. Mortimer, who has devoted many years to a patient investigation of the facts under discussion. If I understand him aright, water, the produce of rainfall, is contained in the chalk, as in a sponge, in the interstices and pores of the mass, and finds its level by gradual infiltration, the line of saturation following to some extent the contour of the surface elevation, rather than that of surface depression. There is nothing whatever to show that the water drains into subterranean streams, which follow the windings of the dales, and are actively engaged in excavating them. This is a pure assumption, met at once by the fact that one of the principal dales, that, namely, from near Acklam Brow to Burdale has a bottom composed of [Kimmeridge] clay, on to the surface of which a subterranean stream from Wayrham to Thixendale (*cf.* Map A) ought to drain, supposing any such existed. But there is none.

Appendix E.

The thick mass of chalk and flint gravel which occupies the bottom of the dales, especially where they debouch on the plain of Holderness, and which is then spread fan-like over the level area, undoubtedly represents the matter mechanically denuded and transported from the valleys in the rear; but, in many cases, not transported far. The general character of the gravel partakes of that of the chalk in the immediate neighbourhood; for example—the gravel one mile south of

Wetwang contains a quantity of flint, and flints of a very large size: so does the present rock; whereas the gravel at Garton Slack, two miles east of Wetwang, contains comparatively few flints, and none of a large size. This again corresponds with the flintless nature of the chalk in this direction.

The deposition of all the bottom gravels shows distinct traces of stratification. There are beds of sand, and clay intercalated in the beds of chalk gravel; and the chalk gravel itself presents different aspects at different altitudes. This points to a sorting and arrangement under water, *i.e.*, under *marine* action, before the sea finally abandoned the fjords of the Wolds.

On the other hand, the beaches alluded to above, on the sides and tops of the dales, exhibit no traces of stratification, nor do they contain large, clean, flattened pieces of chalk, with the edges all rounded, as do the bottom gravels, but consist entirely of small fragments, sometimes rounded, but more commonly angular, as if crushed, and point more to *ice* action than to marine.

Appendix F.

I am indebted to Mr. R. Davison, of Driffield, for kindly analysing for me three samples of water, taken from Wharram, Kirkburn, and Driffield.

No. 1 was taken from a spring near Wharram station, which, in all probability, had not traversed a great extent of chalk rock, either in depth or distance.

No. 2 from a spring at Kirkburn, which probably represents a large drainage area.

No. 3 from the deep bore-hole in the water-bearing area of the chalk in Holderness, which supplies the boilers of the Driffield and East Riding Cake Co.

The analysis is as follows:—

		Grains per gallon.		
		Lime.		Carbonate of Lime.
No. 1.	Wharram	6·82	=	12·18
No. 2.	Kirkburn	6·82	=	12·18
No. 3.	Driffield	7·60	=	13·58

From this analysis, combined with the data given in Mr. Mortimer's paper on the Chalk Water Supply of Yorkshire, which show an area of 420 square miles of exposed chalk, an average of $27\frac{1}{2}$ inches of rainfall per annum, with a deduction of one-fourth for the amount of rain intercepted in various ways, I have constructed the following tables (A and B), worked for convenience by the aid of logarithms:—

TABLE A.

Area of exposed chalk forming the Wolds = 420 *square miles. Average rainfall* = $27\frac{1}{2}$ *inches.*

Analysis of springs gives 6·82 grains lime = 12·18 grains of carbonate of lime per gallon. Worked by the aid of Logarithms.

L. 4840 square yards	3·6848454	
L. 9 square feet	·9542425	
L. 144 square inches	2·1583625	
L. $27\frac{1}{2}$ rainfall	1·4393327	
	8·2367831	= cubic inches per acre per annum.
L. 277·27 cubic inches	2·4429029	
	5·7938802	= gallons per acre per annum.
L. 12·18 grains per gallon	1·0856473	
	6·8795275	= grains per acre per annum.
L. 7000 grains 3·8450980		
L. 112 lbs. 2·0492180	5·8943160	
	·9852115	= cwts. per acre per annum.

Or 9·6652 cwts. per acre per annum chemically removed.

But an allowance of $\frac{1}{4}$th must be deducted for the amount of rain intercepted by ponds, tanks, vegetation, evaporation, &c., the true quantity being about $7\frac{1}{4}$ cwts., instead of $9\frac{1}{2}$ cwts.

Hence—

L. 7·2489 cwts. per acre	·8602721	
L. 640 square acres	2·8061800	
L. 420 square miles	2·6232493	
	6·2897014	total cwts. per annum.
L. 20 cwts.	1·3010300	
i.e., **97,425** tons	4·9886714	tons per annum.

Removed from the chalk area of 420 square miles in chemical solution only.

TABLE B.

L. Cubic in. per acre per ann. *See Table A.*		8·2367831	
L. 1728		3·2375437	
		4·9992394	cubic feet per acre.
L. 640 square acres		2·8061800	
L. 420 square miles		2·6232493	
		10·4285887	ann. rainfall in cubic ft. (*a*)
Also—			
L. Grains per acre. *See Table A.*		6·8795275	
L. 640 square acres		2·8061800	
L. 420 square miles		2·6232493	
		12·3089568	total grains per annum.
L. 70000	4·8450980		
L. 6·2565	·7971636		
		5·6422616	
		6·6666952	cubic ft. chemically removed by above per annum. (*b*)
Hence—			
	(*a*)	10·4285887	
	(*b*)	6·6666952	
	5779	3·7618935	

i.e., fraction of foot by which chalk area is annually lowered $= \frac{1}{5779}$, or 1 foot in 5779 years.

From these it appears that the amount of solid chalk *annually* removed in *chemical* solution, or in the process of turning soft water into hard, amounts to no less than 97,425 tons; whilst, at the same rate, the general surface of the same area is lowered one foot in 5,779 years. *Mechanical* action has not been taken into account, as being comparatively trifling.

ON THE SOURCE OF THE ERRATIC BOULDERS IN THE VALLEY OF RIVER CALDER, YORKSHIRE. BY JAMES W. DAVIS, F.S.A., F.G.S., ETC.

FOUR years ago I had the pleasure of reading a paper before this Society on the Erratic Boulders in the Valley of the Calder. Since then, extended observations have led to a confirmation of the views I then laid before the Society. The result of those observations forms the subject of this communication.

It may assist a proper understanding of the subject if I recapitulate, as briefly as possible, the main facts of the case. The river has its source in two or three small streams which rise in the hills on the Lancashire side of the Pennine Anticlinal. These are joined into one stream, and pass along a narrow but deep valley cut at right angles to the range of elevated gritstone hills which form the boundary between Lancashire and Yorkshire. For five or six miles the valley is rarely more than about 200 yards in breadth, and on each side the slopes of the hills are extremely steep, composed of shales, surmounted by a precipitous grit-stone escarpment. At Hebden Bridge the Calder is joined by the Hebden; in its course south-eastwards the valley gradually assumes larger dimensions, and south of Halifax spreads out into extensive level plains, along which the Calder has carved its channel with many devious turnings. On reaching the district from Mirfield to Wakefield these characteristics are still more apparent, its path being amongst the softer beds of the Coal-measures. Below Wakefield to the confluence of the Calder with the Aire at Castleford, the country generally is of a comparatively flat and uninteresting nature.

The lower reaches of the valley are filled with great quantities of gravels, sand, and boulders. At Wakefield

wells have been dug to a depth of twenty-eight and thirty feet, and at Thornhill and Dewsbury excavations have proved the deposits to be between forty and fifty feet in depth. Still further up the valley, from Elland to Sowerby Bridge, the gravels and boulders occur in some force, and are at least twelve to sixteen feet deep. The valley nearer its source than the latter locality is almost devoid of gravels; and where they do occur, as at Mytholmroyd, the travelled boulders are rare, or altogether absent. From Sowerby Bridge southwards the drift or gravel is composed of rounded pebbles and sand; these, near the surface, are almost entirely derived from the local sandstones and calliards; in the lower strata boulders of granite, trap, and syenite become gradually more frequent, until in the lowest parts they attain a great preponderance, and rocks of local origin are almost as rarely found as crystalline ones were in the upper part of the series. In the sections low down the valley, the boulders are frequently of considerable size, and at Dewsbury masses of granite and limestone were found near the base of the section exceeding a foot in diameter; they were in all cases well rounded and quite devoid of scratches. The following section of a well sunk at Dewsbury may be taken as an average example:—

1. Earth and sandy subsoil	7ft.	6in.
2. Boulders, consisting in the upper part of sandstone with a slight intermixture of granite, etc., gradually merging into	24ft.	0in.
3. Boulders, almost entirely of crystalline rocks not occurring in the district *in situ*	6ft.	0in.
4. Clay with sand and boulders	5ft.	0in.
Carboniferous sandstone		

A remarkable circumstance is the occurrence in the lower beds of rounded masses of flint, along with granite, syenite, and trap rocks, the latter having been identified with their parent rocks in Westmoreland and Cumberland,

and even in some few instances with rocks of Scotch derivation, whilst the flints are similar to those occurring in the Chalk in the eastern parts of the Yorkshire Wolds. There is an entire absence of shells of Mollusca, but near Thornhill the trunks of several trees have been found at a few feet below the surface of the gravel beds presenting an appearance indicating that they grew at no great distance from the position they occupied when found. A more detailed description may be found in the Proceedings of the Yorkshire Geological and Polytechnic Society for the year 1875, page 93.*

In addition to the boulders already enumerated, Shap Fell granite has been found in the district south-east of Wakefield. Though comparatively rare, they are found sufficiently often to form a characteristic boulder; the large masses of pink felspar being a very important constituent, which renders their identification unmistakable. The occurrence of this granite, as will be shown hereafter, throws a most important light on the origin of the gravels.

The question at issue is, "How were the erratic boulders transported into the Valley of the Calder?" There are two sources from which the boulders may have been derived, the one on the western side of the Pennine range of hills dividing Lancashire and Yorkshire, and the other occupying a part of the great plain of the Ouse in the central part of Yorkshire. In all probability the glacial clays, originally containing the boulders, may have had a common origin in the mountainous ranges of Westmoreland, or possibly amongst the mountains of the south of Scotland. Whether one or both these localities served as the source of the glacier, it appears to have passed along the valley of the Eden, grinding against the Crossfell escarpment until it reached

* See also a paper by J. Travis Clay, Esq., of Rastrick, Proc. Geol. and Polyt. Soc. of the West Riding of Yorkshire, vol. i. p. 201 (1841).

the somewhat lower ground of Stainmoor Forest. At this point a part of the glacier was deflected eastwards over hills rising to a height of 1,500 to 1,600 feet above the sea-level into the valleys of the Tees and its tributaries, and also into Arkendale and Swaledale, which are branches from the valley of the Ouse. The glaciers penetrated far down the valleys, and the immense quantities of boulders and till left on their recession testify to their great size and importance. The second portion of the Eden Valley glacier, which did not pass over Stainmoor, continued its course in a southerly direction, and one part of it, filling the valley between Mallerstang and Wild Boar Fell, passed along the district known as Lunds, and may have entered Wensleydale. Mr. J. G. Goodchild* has demonstrated that this glacier must have been 1,600 feet in thickness, and points to numerous evidences of its extent and action in this and the tributary dales of Snaizeholme Widdale and other streams. The remaining portion passed along the western escarpment of the Pennine Chain, and deposited great thicknesses of boulder clays in the valleys of Lancashire. Mr. Dakyns† is of opinion that the latter is the source whence the "erratics may very well have been washed down out of these glacial beds into the Calder valley by ordinary rain and river action," and I believe that this opinion is also shared to a great extent by other officers of the Geological Survey.‡ It has already been observed that the sources of the Calder are extended to the Lancashire side of the Pennine anticlinal, but an inspection of the country drained by it shows that it is surrounded by high hills, with the exception of the

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* Quart. Journ. Geol. Soc., vol. xxxi., p. 73.

† Geol. Mag., New Ser., Dec. II., vol. vi., p. 46.

‡ See also "Notes on the Lancashire and Cheshire Drift," by E. W. Binney, read in 1842, and printed in the Transactions of the Manc. Geol. Soc., vol. viii., part i., page 30 (1869).

two valleys along which the railway lines run north-westwards to Burnley and southwards to Littleborough. The watershed between Burnley and Littleborough is formed by a series of hills rising about 1,400 feet above the sea-level, extending from Shievely Pike and Heald Moor southwards to Tooter Hill and along Trough Edge to the summit near Walsden. Throughout the whole of this district on the Yorkshire side of the watershed, with the exception of a small patch of gravel in Walsden, near the Waggon and Horses public-house, there is no trace of gravel or drift. The beds of the several streams in Dulesgate, Howroyd Clough or Ramsden Clough, though deeply cut, exhibit no sections in which drift can be found. On the western or Lancashire slopes of the hills boulder clays and drift occur, often reaching a thickness of 150 to 200 feet. In excavating Hollingworth Reservoir, which is four or five miles west of the summit, and 568 feet above sea-level, extensive beds of gravels were found, which contained marine shells of the genera *Fusus, Cardium, Purpura, Neritella,* etc. Marine shells in the drift are not uncommon in other parts of the district.

The Yorkshire and the Lancashire Calders rise near together at Calder Head. The latter is fed by many small tributaries which have their source on the slopes of the hills eastwards. These tributaries have formed deep valleys or cloughs, and exposed great thicknesses of gravel and boulder clay. Good examples may be seen in Cant Clough and Hurstwood Brook, near Worsthorn, and in the Catlow and Thursden Brooks. The boulders have been derived from the boulder clay, which still in many instances is found at the base of the drift. The latter is composed mainly of carboniferous limestones and sandstones, with an intermixture of Silurian grits, traps, quartzites, and granites. The carboniferous limestone occurs in such abundance that it

was formerly very extensively used for burning to obtain lime. The remains of lime-kilns may be seen studding the hill-sides throughout the locality. In the valley with Burnley for its centre, the remains of glacial origin occur frequently. The gravels in the valley of the Yorkshire Calder *may* have been derived originally from the boulder beds in these districts, but a glance at the physical features of the district renders this view of the case somewhat problematical. The distance from Todmorden to Burnley is $9\frac{1}{4}$ miles. The two Calders rise at Calder Head, four miles from Todmorden. The valley of the Yorkshire Calder, running south-eastwards, is narrow, rugged, and falls rapidly from a height of more than 700 feet above the sea-level at the summit, to about 380 feet at Todmorden. On either side the valley the ground rises rapidly, and is surmounted by precipitous escarpments of sandstone. The Pennine fault runs in a line with the valley, and has displaced the rocks, so that those on the Lancashire side are composed of the third grit, the opposite one being thick beds of the Kinderscout grit. Surmounting the latter, the picturesque groups of weathered rocks, the Bridestones and Hawkstones, ornament the sky-line. Near the source of the stream the Lower Coal Measures set in, and the sides of the valley being, in consequence, of a much looser and more friable nature, landslips have resulted, producing a great number of rounded hillocks. The Lancashire Calder rises and runs in a similar narrow valley, falling with equal or still greater rapidity in the opposite direction, the bed of the stream at Burnley being 350 feet below that of its source. Beds of gravel are occasionally exposed in the sides of the stream, as at Walk Mill, two miles from its source, and 200 feet less in elevation, where, beneath a bed of peat principally composed of the remains of hazel trees, there is a rough sandy gravel. The contained stones are for the most part semi-

angular, and have all been derived from the neighbouring hills. Granites, limestones, or other travelled boulders, do not appear to be present. Some distance lower down the valley, as Burnley is approached, however, the travelled boulders become common.

If the erratics in the bed of the Yorkshire Calder were derived from the boulder clays east and north-east of Burnley, it is quite evident that they could not have been transported by river action. The great rise to the summit of drainage disposes of that theory. The only agent equal to the task appears to be drifting icebergs. It is possible that large masses of ice may have been in existence in the Burnley valley, and these, becoming loose and floating away, would carry with them any stones or boulders with which they happened to be in contact. In order that these icebergs should be able to float over into the valley of the Yorkshire Calder, it would be necessary that the land should be lowered to the extent of between 750 and 800 feet, so that the sea might overflow the summit to a sufficient depth to afford a passage for the ice-floes and their contents. There are also other objections to this method of their entrance into the valley; amongst others, that the valley is entirely devoid of erratic blocks or boulders for many miles from its source, and it is only when the lower parts are reached that they occur, and the nearer the mouth of the valley the more numerous are the boulders. It might also be expected that some of the boulders would lie strewn on the sides of the hills bounding the valley; but hitherto both the hill-sides and their tops have proved entirely devoid of such evidence. For eight or ten miles the deep valley does not present any sections exposing erratic boulders. At some distance below Hebden Bridge, Dr. Alexander* quotes Mr. Gibson as having found a few

* Proc. Geol. and Polyt. Soc. of the W. Riding of Yorkshire, vol. i., p. 148.

fragments of granite or trap whilst the railway line was in process of construction, and a few well-rounded boulders are occasionally found at Mytholmroyd, two miles further down the valley, but they do not occur in any considerable quantity until North Dean is reached.

Turning next to the second source whence the boulders may have been derived, it is well known that the valley of the River Ouse contains immense quantities of boulder clay, brick-earths, sands, and gravels, derived from the glaciers which it has been shown descended Swaledale and Wensleydale. The boulder clay may be considered as the foundation on which the others are deposited, and where it has not been subjected to the action of water, still extends across the whole breadth of the valley from the elevated Permian limestone plateau on the west to the liassic and oolitic wolds on the east. Sections exposing the relative position of the series in the valley are not frequently exposed. The boulder clay occurs extensively east of Knaresborough, and southwards; and on the opposite side of the valley it is 60 or 80 feet thick near Easingwold. At York the boulder clay is 70 feet thick, and the new railway station works are all built on this material. South of the River Wharfe the clay has a thickness of 60 feet. It contains immense quantities of scratched stones; boulders of mountain limestone are numerous; pink granite, trap, syenite and others, derived from the mountainous districts, are common, and mixed with these there are also boulders of sandstone, chert, and chalk. The centre of the valley is covered with deposits of a more recent origin; sands and gravel occur plentifully, and appear to have been derived from the glacial clays beneath by the disintegrating action of water. The stones are generally more rounded, and the striæ, or ice-scratches, have been removed by attrition. In a few cases the boulders still retain scratches. "These

sands frequently exhibit very irregular stratification, and occasionally the beds are much contorted, as if from lateral pressure, such as might be produced by icebergs grounding in shallow water."*

There is little trace of glacial deposits on the Permian limestone, but on the western side, in the valley of the Aire, there is abundant evidence of glacial action. The hollow in which Bradford is situated is covered with a thick deposit of boulder clay, and at Guiseley and Apperley Bridge patches of similar drift occur. North of Leeds great masses of drift are found, consisting principally of stiff blue clay, containing rounded and angular stones of local origin, as sandstones and grit, and also many others of foreign origin, granite and trap being the most common. At Whinmoor, at a height of 380 feet above the sea-level, a boring went through 114 feet of boulder clay. These deposits are probably the remains of an old glacier which descended the valley of the Aire from the neighbourhood of Skipton. It is within the range of possibility that this glacier may have extended as far south as the neighbourhood of Barnsley, for Prof. A. H. Green has described a bed of glacial clay† filling a basin-shaped hollow about two miles north of that town. The exposure is three-quarters of a mile in length; the boulder clay is divided into upper and lower, and contains, besides stones of local origin, boulders of highly metamorphosed breccia, granite, and others, from the Lake District. There are other patches of glacial clay scattered over the district, and also quantities of drift. From a consideration of all the facts, Prof. Green arrives at the conclusion that the whole district was probably covered by a layer of till or boulder clay, resulting from the presence

* Memoir of the Geological Survey, Illustrating Sheet 93 N.W. p. 14.

† Proc. York. Geol. and Polyt. Soc., 1876, new series, pt. iii., p. 122.

of an ice-sheet which probably had its termination in this district, and, being thin, could not exert a very great influence in grinding up the rocks over which it passed. The greater part of the boulder clay so deposited has since been removed by denudation.

The glacier, whose existence is thus indicated, descended from the northwards, and consequently must have crossed the lower part of the valley of the Calder in the neighbourhood of the place where Wakefield now stands, and several miles west of its confluence with the Aire at Castleford. The facts already stated, though very briefly, go to prove that on the recession of the glaciers which once enveloped the country north of the hills separating the Calder from the Aire, immense quantities of stiff glacial clay, filled with sub-angular, scratched boulders of both local and distant origin, were left filling up the valleys. The land appears at this period to have been submerged to the extent of some four or five hundred feet, and the glacial clays subject to the denuding and abrading action of water. The boulders released from the clay, and rolled hither and thither by the waves, were gradually reduced to a more rounded form, and by the same process the scratches were obliterated. There can be little doubt that to this action is due much of the sand and gravel existing in the valley of the Ouse, and also in the Aire valley, in the neighbourhood of Leeds. The climate appears to have been still cold, and icebergs, broken off from the receding ice-sheet, or masses of ground-ice bearing the boulders frozen from the bottom into their mass, drifted in every direction, and, melting, dropped their burden of boulders in new localities.

Under such circumstances as these the valley of the Calder would be an estuary from the sea, of considerable width at its mouth, and gradually closing inland to a comparatively narrow channel. The united action of the

floating icebergs and the tides would be amply sufficient to account for the presence of the boulders which have already been described. They are most abundant in the lower and wider parts of the valley, and the boulders of distant origin preponderate in number, in every section, in the lowest beds, those higher in the series being for the most part, and near the surface entirely, composed of sand and boulders of local origin. The icebergs would in the first place supply the erratics in the lower beds, and as the ice-sheet still receded, and a warmer climate prevailed, the rolling action of the tides reduced the boulders higher in the series from the rocks of Carboniferous age which surrounded the valley, and were constantly being broken loose by the action of the water wearing away the shales supporting them.

The fact is, that in all the sections which have been noted in the lower part of the valley, the erratic boulders are always most numerous, and that they are much larger in size, frequently a foot or more in diameter, at the base of the section, diminishing in size and frequency higher up until they are lost completely, and layers with only stones of local derivation occur. In the higher parts of the valley, as at Elland and North Dean, where the beds are half the thickness of those at Wakefield or Dewsbury, no large boulders have been found, and they are rarely seen to exceed two or three inches in diameter. There is also a great decrease in the proportionate number of foreign and local stones even in the lowest beds. This arrangement of the heavier boulders at the base of the sections, and especially their localization in the lower parts of the valley, points most clearly to their eastward origin and the sorting action of the sea. Had they come westward by river action, the largest boulders would have been left in that part of the valley nearest its source, or, if carried to their present positions, would have been

disposed indiscriminately with smaller ones throughout the whole section.

That the latter theory is probably the correct one, receives additional support from the occurrence of erratic boulders in the valleys which branch from that of the Calder, as, for example, the Colne. It is quite impossible that these could have come from the west; the river rises on the high moorlands of Millstone Edge and Holme Moss, nearly 2,000 feet above the sea-level, and falls rapidly to its confluence with the Calder at about 200 feet above the sea-level.

Some other peculiar circumstances may possibly be accounted for if we suppose the land to have been submerged to about 400 feet lower than its present level, and at the same time these facts act reciprocally in affording evidence that such was really the case. There are numerous beds of gravel and well-rounded boulders, composed entirely of rocks of local origin, millstone grit, flagrocks, pieces of coal, and the harder shales, and, where the peculiar siliceous sandstone called Calliard occurs in the vicinity, it is found in the gravel or drift. These beds occur on the hill-sides bounding the valleys, and generally at a height of 350 feet, a little more or less, above the present level of the sea. Examples may be seen at Kirklees Park, near Mirfield, at Exley, in the Elland Cemetery, at Mytholm, in a branch valley west of Halifax, and in other places as far westwards as Hebden Bridge. These gravels are quite distinct from those in the bottom of the valley, and are usually found occupying a plateau formed by a gritstone, from which the softer superincumbent shales have been denuded. In each of the situations cited above they are at least a hundred feet higher than the present level of the valley. Where exposed in section, they are current-bedded, with thin layers of sand intermixed, and present every appearance of having been subjected to tidal action. The presence of these beds has

been accounted for in a variety of ways; but the one I now suggest—that they were the shores of the old sea—perhaps appears the most reasonable when considered in connection with the drift deposits filling up the base of the valley. If they are the remains of the shores of an old lake, as some authors have described them to be, there remains the difficulty of damming up the waters to so great a depth, which does not appear probable, and of which there is no evidence at present existing.

In conclusion, the evidence that the erratic boulders in the valley of the Yorkshire Calder were derived from the sources so plentifully supplied in the great valley occupying the whole of the centre of the county, rather than from the district westwards of the summit of drainage, appears conclusive. In the one case we have the source of the Calder bounded by a series of hills rising to a height of 1,500 feet or more, and the only openings being at Calder Head on the northern and at Hollingworth on the southern part of the Chain. In either of these the land rises rapidly from the Lancashire side to the height of 610 feet and 700 feet respectively, and in each case they form the summit of drainage. All evidence proves that the general form and direction of the valleys remains unchanged since pre-glacial times, and this being so, the ordinary action of rivers being the agent which has carried the boulders from the Lancashire districts over the summits of drainage may be dismissed as out of the question, and, along with it, the theory of some of the early geologists, of a great wave of translation which was supposed to have swept across the Atlantic to our shores, and was made answerable for every unaccountable phenomenon in surface geology presented to their notice. A more probable theory is that they were carried over by icebergs; but this necessitates that the land be submerged to the depth of 700 or 750 feet, and, if that be granted, there

can be no reason why the ice-floes should not have been occasionally stranded on some of the higher lands below the level of the water, and there have left evidence of their presence in heaps of travelled boulders, as well as in the lower parts of the valley. But such evidence is entirely wanting.

On the other hand, the glacial clays are extended across the mouth of the Calder, and the boulders derived from them may have been washed into the valley, during a slight submergence, by the action of the tides and waves, and also borne up the valley by ice-floes. The statement of Prof. Green that a glacier at one time extended as far south as Barnsley, and left its detritus spread over the country northwards, furnishes a source for the boulders actually within the valley of the Calder as far west as Wakefield, and during the denudation of this district by marine action the boulders would be naturally washed into the sheltered bay which the valley under those circumstances would form. It is not necessary that the land should be submerged more than 250 or 300 feet; but if it was lowered to the extent of about 350 feet, there is evidence of its former presence in the beds of sand and gravel which are found in many places on the hill-sides at a nearly uniform height above the sea-level.

THE TRIAS OF THE SOUTHERN PART OF THE VALE OF YORK.

BY H. FRANKLIN PARSONS, M.D., F.G.S.

In a paper which I had the honour to read before this Society in 1877, on the Alluvial Strata of the lower Ouse valley, I described briefly the Triassic rocks upon which the newer beds rest; but, as some further details concerning them have since come to my knowledge, I have thought it proper to bring them before the Society, so that if thought fit, they may be embodied in the Proceedings. This

seems the more desirable inasmuch as the information yielded by well-sections, if not put on record at the time, cannot always be obtained afterwards.

The two members of the Trias—the Keuper, or variegated marl, and the Bunter, or new red sandstone—occupy a wide low-lying plain, between the hills formed by the outcrops of the chalk, oolites, and lias, to the east, and the magnesian limestone to the west; the soft and easily-weathered nature of the triassic marls and sandstones having caused it to undergo a greater amount of disintegration than the harder limestones. Over this area the trias is, for the most part, covered up with the gravels, sands, clays, &c., mentioned in my former paper, only isolated patches rising to the surface. These patches are the summits of mounds of trias left by erosion, while the intermediate hollows have been filled up and levelled over with the recent deposits. Similar mounds, not reaching the surface, may be traced in places under the alluvial deposits by means of well-sinkings. The junctions of the trias with the lias above, and with the magnesian limestone below, and also that of the two beds of the trias with each other, are concealed by the newer deposits, so that it is difficult to make out the relations of the beds to each other, and their respective thicknesses. The line of strike of the chalk, oolites, lias, and Permian strata, being in south Yorkshire and north Lincolnshire, nearly due north and south, it may be assumed, without much risk of error, that the strike of the intermediate trias is also north and south, and the dip therefore to the east.

The Keuper, where met with, presents its usual characters as a red and green marl, with indurated shaly bands, and layers of gypsum. It rises to the surface in the Isle of Axholme, forming a low hill, extending from Haxey, by Epworth, to Belton; and another at Crowle, in Lincolnshire; and it is reached, by borings, at Reedness, Goole,

Hook Bridge, and Staddlethorpe; but the only place in the south of Yorkshire where it is superficial is at Holme-on-Spalding Moor, where it rises into a detached hill 150 feet high. A subterranean ridge appears to extend eastwards from this hill towards the lias at North Cliff; the red marl is met with at a depth of 7 feet, in marl pits on Cliff Warren; while in others, north and south of that, as those at Bealsbeck, described by the Rev. W. V. Harcourt, in the *Philosophical Magazine*, in 1829, a greater depth, 27 feet or more, was attained before meeting the red marl.

All geological maps that I have seen err, following Phillips, in attributing a much too great superficial extension to the trias in this part of Yorkshire; thus it is shown over a large tract in the East Riding, about Riccall, Howden, Staddlethorpe, and other places, where well-sinkings prove that it is covered up with some 50 feet of sand, laminated clay, &c. I believe that the bed of yellow sand, No. 4 in my previous paper, above the laminated clay, has been mistaken for the new red sandstone,—hence the error.

I know no place nearer than Gainsborough where the passage of the Keuper into the lias is shown; but it is very possible that the Rhœtic beds may some day be met with in well-sinkings, along the edge of the lias, between Market Weighton and Brough. In the cutting of the Great Northern Railway, between Gainsborough and Lee, an excellent section is exposed, showing the passage of the Keuper through the Rhœtic beds into the lower lias. The Rhœtic beds are represented by black shales, crowded in places with *Avicula contorta*, and I found one scale of Lepidotus.

The junction of the Keuper with the Bunter is nowhere exposed superficially, but was met with at a depth of 342 feet in borings at Reedness.* In my former paper I gave it as

* See Section 3, *Trans. Yorks. Geol. and Pol. Soc. for* 1877, p. 231.

my opinion that the line of junction must lie somewhere between Goole and Hook; I am now able to fix it with certainty as passing under Goole. In a well sunk in 1878, in Old Goole, the Keuper was reached at a depth of 46 feet; it was only pierced to a depth of 8 feet, and the Bunter below was not reached. In wells about 200 yards to the west, the Bunter is reached without any superjacent marl, at a depth of about 60 feet.* The boundary line between the two formations must therefore lie somewhere between these two points. This conclusion is corroborated by the fact that if we mark on a map the places where the red sandstone and red marl are exposed, or have been struck in borings, and draw a line north and south—the direction of the strike—through Goole, all the places where the Keuper occurs will lie to the east of that line, and all the places where the Bunter occurs to the west of it, with the solitary exception of Reedness, an exception of the kind that proves the rule, for here the red sandstone was struck at a depth of 342 feet, beneath a thickness of 292 feet of red marl. (The white gritty sandstone met with at Sandtoft, section 1 in the Appendix to my former paper, was, I have now no doubt, Bunter and not Keuper.)

From the above data we are able to calculate approximately the dip of the triassic strata, and hence their thickness. The dip of the new red sandstone cannot be made out in any of the sections in which it is exposed on the surface, in consequence of its being always strongly false-bedded; nor by comparison of different well sections, owing to the absence of beds marked by characteristic fossils, or constant and recognisable lithological characters; but the junction of the red sandstone and marl, if no marked unconformability exists, furnishes us with the required landmark.

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* Section 5, loc. cit., p. 233.

It happens, fortunately for our purpose, that the site of the boring at Reedness is just three miles due east, as the crow flies, from Old Goole, and the surface-level may be taken as the same at the two places. If, therefore, we find that the upper surface of the Bunter is reached at Old Goole at 60 feet, and at Reedness at 342 feet, *i.e.*, 282 feet lower, an exceedingly simple calculation will prove that the dip (in the absence of faults) must be 94 feet per mile, or 1 in 56; this is equal to an angle of 1° to the horizon. Assuming the dip to be the same east of Reedness and west of Goole, as between those places, we can calculate the thickness of the strata. From Goole to the hills east of the Trent, where the lias comes out above the Keuper, is $7\frac{1}{2}$ miles in a direct line; this would give $7\frac{1}{2} \times 94 =$ about 700 feet as the thickness of the Keuper. In the same way, the breadth of the belt of Bunter, from Goole to the magnesian limestone hills about Knottingley, being $13\frac{1}{2}$ miles, the thickness of the Bunter will be 1,270 feet. This is considerably greater than that given in the sections of the Geological Survey, which show it to be only 500 feet; but that this thickness is under estimated, is shown by the fact that the Reedness borings penetrated the Bunter for 689 feet, and those at New Bridge, five miles west of the edge, for 500 feet, without reaching the bottom.

The Bunter is exposed about Tickhill, Doncaster, and Finningly, and other patches occur at Barnby Don, Hatfield, Wroot, and Thorne. A low ridge extends nine miles east and west from Cowick to Kellington, and is prolonged eastwards under the alluvial strata to Rawcliffe and Goole. There are also detached patches at Whitley, and another north of the Aire at Carlton and Camblesforth. West of Selby it rises into two hills, Brayton Barf (175 feet) and Hambleton Haugh (150 feet). It is struck in borings at Sandtoft, Goole, Rawcliffe, Temple Hirst, Selby, Osgodby,

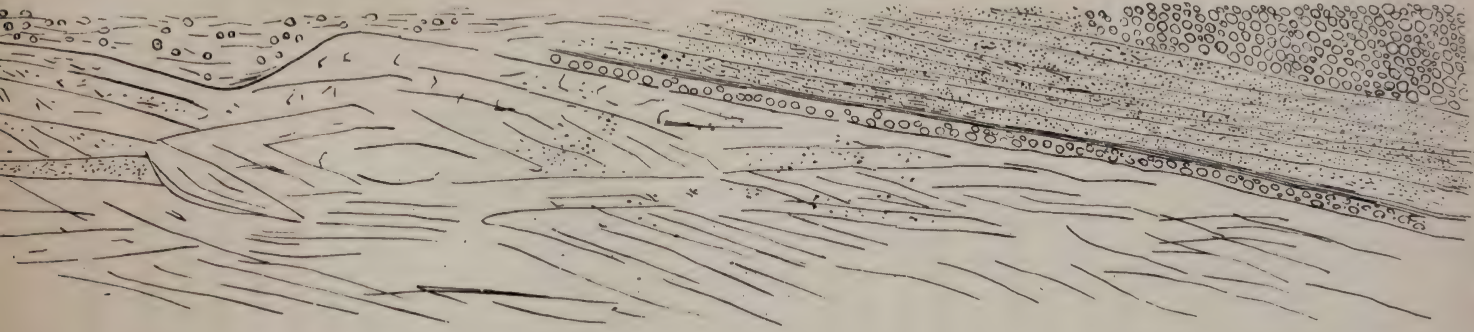
and Cawood. Where it approaches the surface, the red sandstone is almost always covered up with a gravel consisting of waterworn boulders of carboniferous sandstone and millstone grit, with intercalated layers of red sand, composed chiefly of its own *débris* rearranged, which sometimes so closely resemble the original rock *in situ* as to be liable to be mistaken for it, as in the section at Balby, near Doncaster. The usual character of the Bunter in all these places is a loose red sand, or friable, semi-coherent red sandstone, always strongly current bedded, often micaceous, with clayey bands, and with occasional partings or pockets of red, green, or yellow ochrey marl; occasionally, however, it loses its red colour and becomes whitish or cream-coloured. It contains no fossils. In the maps of the Geological Survey, it is divided into two beds, "f1, lower red and mottled sandstone," and "f2, pebble beds or conglomerate," I presume to correspond with the divisions in other parts of the country, but I can see no difference whatever in lithological characters between the two, and in the absence of fossils it is not easy to see how they can be distinguished. I have never in this neighbourhood seen the Bunter assume the form of a conglomerate, as it does in other districts, *e.g.*, at Nottingham. It is, however, impossible to suppose that the Geological Survey can have mistaken the drift gravels mingled with the rearranged materials of the red sandstone, as previously alluded to, for a conglomerate of Triassic age.

I know no place where the relation of the Trias to the Permian can be seen. In most places the alluvial strata overlap the edge of the magnesian limestone. At Balby, near Doncaster, and about Tickhill, the red sandstone is superficial, where it rests upon the limestone; but I know of no section where the junction is exposed. It would be interesting to ascertain the relation of these beds to each other. As we all

know, the line between the palæozoic and secondary series of strata is drawn, on palæontological grounds, between the Permian and the Trias; and in the south of England, where the Permian is wanting, the hiatus at the base of the Trias is as strongly marked as that between the chalk and the eocene. The varying degree to which, as shown on the maps of the Geological Survey, the upper magnesian limestone is overlapped by the red sandstone, would seem to indicate that there is some amount of unconformability between them. In lithological characters, however, there seems to be a gradation between the two. At Hexthorpe, near Doncaster, the upper beds of the limestone are of a reddish colour, with partings of variegated red and green marl, and above them is a red sandy marl. In some places, as at Monk Fryston, there is a red marl with layers of gypsum closely resembling the Keuper marl, marked "e5" in the Geological Survey map, which rests on the upper limestone. The only place where I have seen the red sandstone in contact with the limestone is in a quarry by the side of the railway at Monk Fryston, about half-a-mile south of Milford Junction. Here there is a fault recently exposed in cutting a new roadway into the quarry, and not shown in the Survey map, running nearly east and west, with the downthrow on the south, which has elevated the magnesian limestone into juxtaposition with a red and cream-coloured sandstone, which, though marked "e5" Red Marl, in the Survey map, can hardly, I think, be anything but the Bunter sandstone. Altogether, the relations of the Trias and Permian form a difficult but interesting subject, well worthy of being worked out by an abler geologist than myself, in the way that our excellent Secretary has worked out those of the Permian and the Coal Measures.

Fig. 1.

SAND PIT AT BALBY, NEAR DONCASTER.

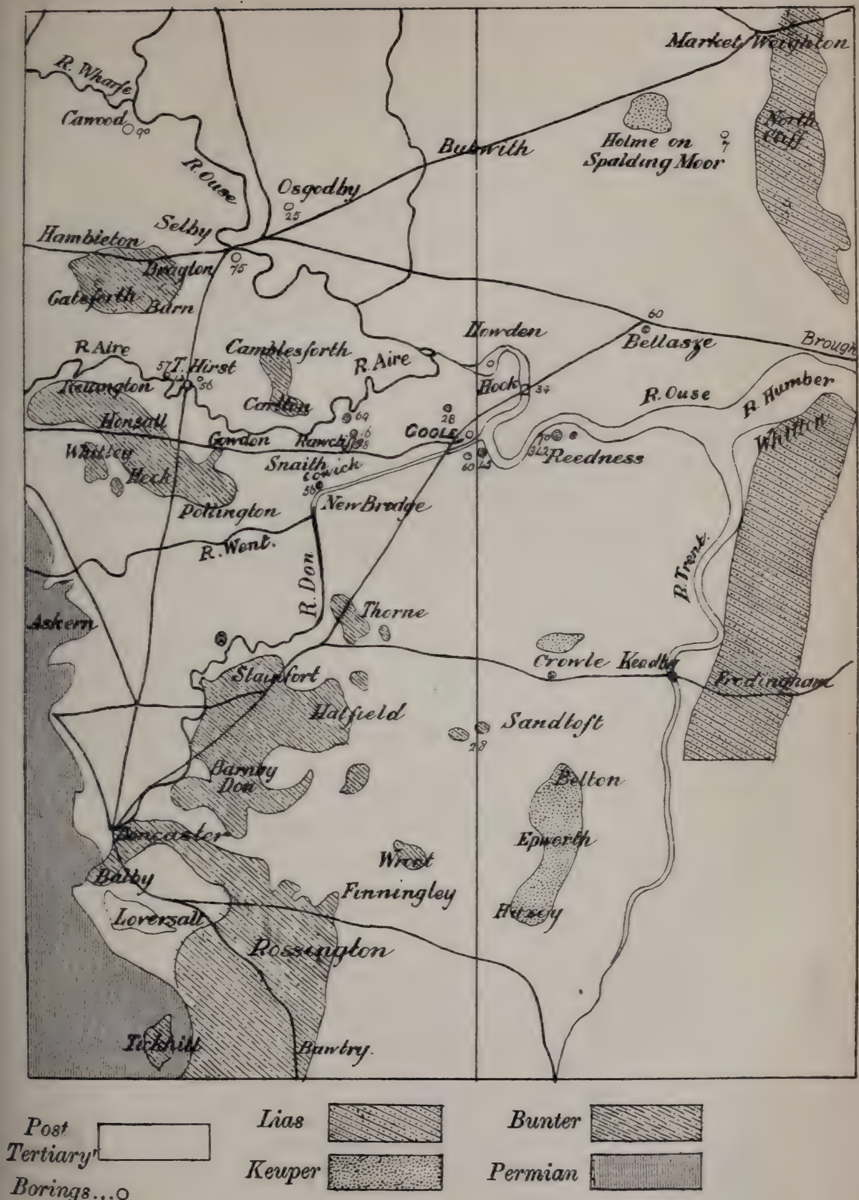


1. *Sandy Clay, with Boulders of Sandstone and Millstone Grit apparently resting upon Gravel bed.*
2. *Coarse Loose Gravel.*
3. *Red Sand regularly bedded, closely resembling Bunter, but more regularly bedded, and loose and incoherent without red marl, but with partings of Brown Clay.*
4. *Thin layer of Brown Clay, two inches.*
5. *Narrow band of loose Gravel, six inches.*
   The three preceding resting conformably one on the other, and dipping at an angle of five degrees to sight.
6. *Bunter Sandstone. Red semi-coherent sand rock, strongly cross bedded, and with partings of red and green marl.*

H. F. Parsons, Del.

M'Corquodale & Co., Lithographers, Leeds.

Fig. II.



Figures = depth in feet at which the Trias has been found.

H. F. Parsons, Del. M'Corquodale & Co., Lithographers, Leeds.

APPENDIX.

SECTION 1.

Well at Gleadow's Buildings, Old Goole. Deepened in 1878.

	THICKNESS. Ft.	In.		FROM SURFACE. Ft.	In.
Old Well	10	0	...	10	0
Quicksand	11	0	...	21	0
Laminated Clay	13	0	...	34	0
Stiff Sandy Warp	11	0	...	45	0
Gravel (rounded chert pebbles)	0	3	...	45	3
Stiff Reddish Clayey Marl	0	6	...	45	9
Blue and Red Marl	1	0	...	46	9
Red Marl	8	3	...	55	0
		To bottom.			

Particulars from Mr. E. C. B. Tudor, Surveyor, Goole.

SECTION 2.

Marl Pit at Cliff Warren, near Market Weighton.

	THICKNESS. Ft.	In.		FROM SURFACE. Ft.	In.
Surface Soil	0	6	...	0	6
Yellow Sand, with peaty layers indented by a subjacent bed of gravel consisting of chalk flints	3	0	...	3	6
Laminated Clay	2	0	...	5	6
Sand and Gravel (containing chalk flints, fragments of Keuper Marl and Gryphæa incurva	1	6	...	6	6
Keuper Marl		To bottom.			

H. F. P.

April 20th, 1878.

SECTION 3.

Well at Bellasize, near Staddlethorpe. Sunk in 1878.

		THICKNESS. Ft.	In.		FROM SURFACE. Ft.	In.
1	Top Soil	1	0	...	1	0
2	Sandy Warp	1	0	...	2	0
3	Laminated Clay, with sand on one side	5	0	...	7	0
4	Clay, with Warp Sand	11	0	...	18	0
5	Blue Clay	12	0	...	30	0

		Thickness. Ft.	In.		From Surface. Ft.	In.
6	Grey Sand	0	6	...	30	6
7	Red Marl	10	0	...	40	6
8	Blue Clay	6	6	...	47	0
9	Flint or Stone	3	4	...	50	4
10	Sand and Soft Warp, with water ...	9	0	...	59	4
11	Red Marl, with Gypsum	12	0	...	71	4
12	Dark Clay, very tough	4	0	...	75	4
13	Red Marl, with white matter ...	4	0	...	79	4
14	Bluish Stone	1	0	...	80	4
15	Red Marl	5	0	...	85	4
16	Grey Sharp Sand	2	0	...	87	4
17	Red Bind, very tough	5	0	...	92	4
18	Blue Bind	2	0	...	94	4
19	Red Marl, with Gypsum	8	0	...	102	4

Particulars from Mr. W. Wetherill, Sanitary Inspector, Selby.

N.B.—In this section I consider the Keuper to commence at No. 11.

SOME ACCOUNT OF THE FOSSIL PLANTS FOUND AT THE DARFIELD QUARRIES, NEAR BARNSLEY.

BY STEPHEN SEAL, F.G.S.

I MAKE no pretensions to a minute and varied knowledge of the science of Geology. I do not pretend for one moment to add anything new to the store of geological lore already gathered. My aim is simply to place on record some account of the fossils found in the Darfield Quarries.

These quarries are part of a belt of carboniferous rocks running from Heath Common, near Wakefield, *via* Chevet, Royston, Cudworth, Darfield, Mexborough, Chesterfield, and nearly as far as Derby, with variations in the texture and quality of the grit. The specimens I shall bring before you, so far as I am aware, are not to be found in any of the districts I have mentioned in such abundance as at Darfield. Small specimens of the Calamite and Lepidodendron are occa-

sionally met with in the Mexborough rocks, but those I have seen are very small in comparison to the Darfield specimens.

The position of these rocks runs north-west by north, and at Darfield they are 150 feet above the level of the sea. The most common fossil is the Calamite cannœformis, so called from the reed-like jointings of its stem. It is found about twenty-five feet from the surface, and generally in a horizontal position. Hugh Miller says these organisms are never found in ironstone measures, and he is probably correct; but some of the specimens from these quarries contain a large percentage of iron. They are eleven inches in circumference, and are fluted vertically with from 104 to 130 ribs: the joints are generally from two to two and a half inches apart. In these specimens we have little or no trace of any bark. Other specimens do not contain iron, but are pure siliceous grit, containing nothing of their once vegetable nature except the form. This species I consider to have been less ligneous than the Calamites mougeotii, which is occasionally found, and presents an appearance of having been burst or flattened. Its joints are more numerous than in cannœformis; and, from the occurrence of small holes in the joints, stems or leaves appear to have branched out from each joint, throwing off foliage forming canopies one above the other. Perhaps I may be permitted to remark that some of the designs now used, and many that are obsolete, have had their origin in the wonderful works of creation. I am told that the handles of some of the early specimens of Sheffield cutlery known as "Irish Cooks" are exact imitations of one species of Calamite.

I now notice the *Sigillaria.* I believe more than twenty different species have been enumerated from the British coal-fields, but I have not noticed more than five or six kinds in the Darfield rocks; but the specimens there are, I

think, more perfect and beautiful than those in the coal measures.

Specimens of Stigmaria ficoides, deriving its name from the stigmata or punctures which ornament its surface, are also common. This genus is found in the same deposits, but generally slightly lower down. The Stigmaria is now understood to be the root of Sigillaria, Lepidodendron, &c., and usually occurs as an underground stem in the shale or ancient mud in which it grew. It is more or less round, sometimes compressed, studded with circular pittings arranged in spiral order round its surface. Sir Wm. Logan was the first to point out that every bed of coal rests on a peculiar clay, containing vegetable fossils known as Stigmaria, which pierce it in every direction, suggesting the idea of their being roots. Mr. Binney concurred in this view. If this theory be correct, it is somewhat remarkable to find such specimens as these in the sandstone rocks, which were probably formed thousands of years subsequently to the vast vegetable deposits which have resulted in our coal beds.

I now notice the Lepidodendron Sternbergii. I think its nearest living representative is the club-moss commonly called Stag's Horn: it differs from the other specimens by the scaly appearance of its bark. It is mostly found in deeper deposits than the specimens previously mentioned, generally about forty feet from the surface. It is most common in the strata overlying the best beds of white sandstone rock; and sometimes, to our disappointment and loss, we find it running completely through our best beds of stone.

A comparatively rare genus of fossil plants named Halonia is occasionally found. It somewhat resembles Sigillaria. I find the markings as follows: protuberances, or nodules, which are twisted or contorted and not very regularly placed, with slight or faint Lepidodendroid markings between and surrounding the protuberances.

Modern students in geology have accepted the view that most of our coal-forming plants have grown on the spot where the beds of coal now exist. Professor Green, in his admirable work on "Geology for Students," while admitting that we occasionally meet with coal which has been formed under water from masses of drift timber and plants carried down by rivers and buried among mechanically aggregated deposits—such coal occurring rather in lenticular patches than regular beds, and apt to be impure from mixture of earthy sediments;—arrives at the same conclusion as Logan, Binney, and others, that the underclays are old terrestrial soils, and that the trees and plants which grew upon them dried and fell to the ground, forming a layer of nearly pure vegetable matter. After a time, the surface was lowered beneath the water, but so gently that the soft pulpy mass was not disturbed; sand and clay were deposited above them, and the band of dead plants was thus sealed up, and afterwards converted, by pressure and chemical changes, into a seam of coal. From distinct isolated specimens of the species I have named, which are found in the stone amidst the coal beds, we discover the nature of the plants of this era; but the later deposits in the sandstone rocks are more perfect—in fact, so clear and distinct are some of them, that in many instances even the bark of the Stigmaria and Lepidodendron may be seen, but it is mostly decayed to a black powder.

Calamites resembled the horse tail more nearly than any other living plant. The fossil specimens, however, were of enormous magnitude compared with the dwarfish examples of our own day, and appear to indicate a temperature which may be compared with the tropical climate of the present time. Many geologists hold the opinion that the large specimens found in our carboniferous rocks and coal measures are the result of high temperature obtained otherwise than that of tropical regions, and that the earth

was originally an incandescent or highly heated mass, and was gradually cooled down sufficiently to render the early gneiss and mica schist crystalline; cool enough during Grauwacke and Silurian eras to permit of marine corals, shell fish, or crustacea; cooler still during the life of the plated fishes of the old red sandstone; and sufficiently genial throughout the carboniferous period to foster a growth of terrestrial vegetation over the surface. It is thought by Brogniart and others that this high and uniform temperature, combined with a greater proportion of carbonic acid gas in the atmosphere, would sustain the gigantic and prolific vegetation necessary for the formation of beds of coal. Thus all the conditions would have arisen for extensive deposits of vegetation, which would, in course of time, with the accumulated weight of superincumbent deposits, undergo a state of petrifaction by the waters passing through the different deposits of sand and mud; and thus, through the lapse of untold ages, become completely stripped of all vegetable matter and be turned into stone, some of them being largely impregnated with iron.

In conclusion, I venture to give an opinion upon a point on which geologists differ, namely, as to whether the contortions and breaks in our rocks are the result of an upheaving agency. I grant that some of the rocks are so broken and contorted that they have the appearance of having been subject to internal pressure, but my opinion is that the breaks or joints that we find have gradually taken place during the period of their deposition, and are not the result of upheaving convulsions. However, my object has not been to advance any crotchets of my own, but simply to place on record some account of the fossils found in the Darfield rocks.

ON THE DIVISIONS OF THE GLACIAL BEDS IN FILEY BAY.

BY G. W. LAMPLUGH, F.G.S.

Upon examination, the interesting, but hitherto neglected, drifts which fill the old preglacial hollow between Filey and Speeton are found to comprise in their sections a fuller series than is elsewhere to be seen in East Yorkshire, instead of all being included, as was supposed by Messrs. Wood and Rome, in but one division of their glacial series, that to which they have given the name of "Purple Clay without Chalk." *

So long ago as 1868, Professor Phillips,† in a short paper on the Hessle drift, pointed out that it was probable there were really two, or even three, boulder clays north of Flambro'; and, in a more recent paper, Mr. S. V. Wood ‡ remarks that he and his colleague, the Rev. J. L. Rome, subsequent to the publication of their joint paper, traced the Hessle clay to the borders of Durham, though this does not seem to refer to the coast section.

So far from these drifts, then, being without division, we shall see that they may be clearly separated into even more than the three clays suggested by Professor Phillips, the divisions thus obtained being clearly the northern representatives of the clays seen in Holderness.

It is not, indeed, strictly necessary to suppose that each of the dividing lines which can be traced in these drifts marks a long "interglacial period." Whether they do or not is a matter of theory; but they are worthy of attention, even if looked upon simply as forming good lines of division, in the same way that the adjacent Neocomian clays of Speeton have been divided into numerous well-marked zones.

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* Quart. Jour. Geol. Soc., Vol. xxiv., p. 147. † *Ibid.*, Vol. xxiv., p. 250.

‡ Geol. Mag., Jan. 1878, p. 17.

Nevertheless, there is evidence which convinces me that long and wide-spread breaks have occurred in the forces which brought together these clays.

At the base of the drift at Speeton is a band of very fine earthy chalk-rubble, resembling rain-wash. This bed is seen on both sides of the gully known as Speeton Gap, and may be traced from the Chalk Escarpment to the point where the Secondary (Neocomian and Kimmeridge) clays sink to the sea-level in New Closes Cliff, a distance of about three-quarters of a mile; and in an interesting exposure on the beach near Reighton Gap, nearly a mile further north, which I recently had an opportunity to examine, it still held its place between the drift and the Upper Kimmeridge Shale, which here formed the underlying bed.

At Speeton Gap this chalky rubble has a thickness of about ten feet; but in the exposure on the beach at Reighton it was much thinner, and probably dies out a little further to the north.

This bed may be of the same age as an exactly similar rubble which is seen on most of the preglacial chalk valley-slopes south of Flambro', and which holds a like position between the drifts and the underlying secondary strata.

Closely associated with this chalky rubble at Speeton is the Sand-bed containing a few species of shore-shells, to which Professor Phillips first drew attention,* and which was believed by him to belong to the drift series.

I have lately seen, however, that it is distinctly older than any boulder clay in Filey Bay; and as a representative of the oldest Yorkshire clay will presently be shown to occur here, it follows that it is older than any Yorkshire glacial deposit.

This shell-bed is first seen in the cliff a few hundred yards

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* "Geology of Yorkshire," 3rd ed., p. 101.

north of Speeton Gap. It is here that it was observed by Professor Phillips, and at this point it is 105 feet above high-water mark, but appears to sink rapidly over the steep denuded slope of the Secondary clays, as I have found traces of it considerably lower in New Closes Cliff, and again along the cliff foot as far as the ravine known as The Gill.

But as this interesting deposit has no direct bearing on the division of the drift, it will be unnecessary on this occasion to enter into further details respecting it.

In the exposure already mentioned, which I saw on the beach opposite to the village of Reighton, and which was afterwards visited by Mr. Dakyns and myself, the following sequence was observable, the beds apparently dipping towards the cliff, commencing with the lowest beds, those nearest low water :—

1. Highly contorted Upper Kimmeridge Shale.
2. Thin band of black silty mud, with broken fossils, being a re-arranged form of the underlying clay.
3. Band of fine Chalk rubble, with a streak of sand.
4. Brown Boulder Clay, with many stones—no shells.
5. Bluish Boulder Clay, with Shells, and with streaks of clean clay containing many Shells, mostly crushed.

   NOTE.—These Shells had a facies totally different from that of the previously mentioned Shell-bed.

6. Patches, here and there, of a clean brown clay (without stones).
7. Greenish-purple Clay, with a few Shell fragments.

The exposure in which this series was seen was about 500 yards in length by 30 in breadth.

Here the next bed above the Chalk-rubble was a band of brown Boulder clay, with many stones. Of course, as this was a horizontal exposure, and the angle of dip being also uncertain, it was impossible to estimate exactly the thickness of this band, but it did not seem to exceed three or four feet.

As I do not know of another section in Yorkshire in

which the bottom of the "Basement" clay has been clearly seen, it is impossible to correlate this bed with any elsewhere, and equally impossible to say whether it is merely a local patch, belonging to the so-called "Basement" clay, or is really an older clay; but at Dimlington, south of Withernsea, where the thick "Basement" clay is seen in the cliff, the great depth which must occur between it and the chalk, which is far beneath the surface, renders it quite possible that there may be other glacial beds between them, older than this so-called "Basement" clay. If this be not the case, the "Basement clay" must be here of immense thickness.

The Boulder clay overlying this Brown band I immediately identified as being the same, in all respects, as the "Basement" clay at Bridlington and elsewhere. It was of a bluish tinge, and contained a considerable quantity of chalk. It also contained many shells of the same species as those found by me at Bridlington. But besides the shells, which were scattered indiscriminately through the clay in the same way as the boulders, and were generally broken, there were also some curiously-twisted streaks, formed in part of a fine blue clay, free from stones, and in part of a dark clayey sand. These streaks contained many shells, Cardita borealis being particularly abundant. Nearly all these shells were crushed, and the fragments somewhat separated, as though through the shearing of their clayey matrix. These streaks have their exact counterpart in similar, though more considerable, patches at Bridlington, which form outliers to the shelly mass long known as the "Bridlington Crag." They are probably the remnants of an old sea-bottom of sand and mud which the ice-sheet has almost obliterated, and from which come the shells now seen in this Boulder clay.

I do not know that this clay can be seen in the cliff anywhere in Filey Bay, and had I not witnessed this exposure, I should have remained ignorant of its presence there. It

has, no doubt, been at one time of far greater extent, and has been so extensively denuded as to leave but this patch remaining, nearly in the centre of the old valley.

The upper surface of this clay was very irregular, and here and there, there remained between it and the next Boulder clay patches of a Brown clay without stones, agreeing with the Middle Laminated Band which has its place between the Basement and the Purple clays at Bridlington.

Over these patches, and where they were absent, resting directly on the "Basement" clay, in strongly-marked contrast, was another Boulder clay, which was the highest bed seen in this exposure, and was continued into the cliff.

Where seen in the cliff, this bed is of a dark purple colour, and when dry has a decidedly greenish tinge. It contains a few shells and shell-fragments, and also pieces of chalk bored by Pholades and Clionæ.

It forms the base of the cliff from near Speeton to Filey, and is also well developed in Cayton Bay, at Scarbro', at Robin Hood's Bay, and at Whitby,—and in fact, in all the sections on the coast where the drift is of any depth.

It is sometimes of great thickness, as near Hunmanby Gap in Filey Bay, where it has a height in the cliff of over forty feet.

This Boulder clay, which is clearly the representative of the "Purple" clay division south of Flambro', has a very uneven upper surface, and in some of the hollows thus formed are gravels and the laminated warps which will be again referred to.

Over these, and where they are not found directly over the Greenish-Purple clay, is another Boulder clay of a well-pronounced brown colour, which is also often very thick. In cases where it rests directly on the Purple clay, without any intercalation (as at Hunmanby Gap, where there is one of the clearest examples of this kind), the only distinction

between them is in colour, and though this is so well-marked as to enable one to point out with certainty to the exact spot where the one ends, and the other begins, yet there are many who deem divisions marked by colour to be unsatisfactory, and who would therefore look upon this as insufficient evidence to warrant a separation.

Fortunately, however, testimony of a more convincing kind is not wanting to show beyond doubt that, even allowing for possible contemporaneous denudation, a considerable time must have elapsed between the formation of the lower Purple clay, and of the upper Brown bed. It is also a useful illustration of the value, as lines of separation in this part of Yorkshire, at least, of these definite colour partings.

The evidence referred to is found in the presence of a broad deep hollow in the lower clay, between Reighton and Hunmanby, which has not only been scooped out, but has also been completely filled in again with finely laminated sands and warps, in places nearly 40 feet thick, almost free from pebbles, save a few coal specks. On each side of the hollow, which is 500 yards across, the Brown clay rests directly upon the Greenish-Purple clay, but when it reaches the southern edge of the hollow, instead of following the steep cliff-like slope of the lower clay, it continues along the same level, thus admitting the intervention of the laminated warps, which completely fill the intervening space. These warps at first dip steeply down the side of the hollow, and are also slightly contorted towards the top, but for the most part they are very even and regular. The northern end of the hollow is much obscured by slips; but shortly after the laminated clays cease to be seen in the cliff, a clear section shows the two Boulder clays to be once more in contact.

This Brown clay is strongly developed in the cliff near Filey Brig, being there of great thickness, and still resting upon Purple clay with a green tinge.

It is also traceable along the coast as far as Whitby, beyond which I have not yet examined the sections.

It seems to have no representative at Bridlington, but reappears further south, between Hornsea and Withernsea, and is well seen at Dimlington, six miles south of the latter place. It does not seem to have been treated before as a separate clay, but it certainly has as good a right to be so considered as have any of the other divisions.

It contains a few small shell fragments.

The next Boulder clay, which nearly always forms the top of the cliff, is red in colour, and shows, in some places, ashy-blue facing to its fissures.

In these sections it but rarely attains to, and never exceeds, a thickness of 12 feet. It is more earthy and broken than any of the other clays, and contains few stones of any size. Amongst its few Boulders, however, I noticed a piece of shale which showed very distinct scratches.

It sometimes lies directly on the Brown clay, in which case the division between them is not very distinct, but oftener a band of sand and gravel separates them. This gravel, which is often very coarse and bouldery, is generally from one to four feet in thickness; but just north of Hunmanby Gap it swells out so as to have a thickness of nearly thirty feet, and here the top red clay passes into it for a short space. These gravels, also, sometimes admit into their midst a thin band of very dark greenish boulder clay, which is not, however, regular and continuous enough to be separated from them.

I do not hesitate to identify this top red clay, which forms the capping bed to nearly all the sections between Speeton and Filey, with that to which, on the Holderness coast, Messrs. Wood and Rome have given the name of "Hessle Clay," and which, as is mentioned in the commencement of this paper, these gentlemen have traced inland "through the vale of York into that of the Tees;" but

which they do not seem to admit into the coast sections north of Flambro'.

The complete Filey Bay section, therefore, would appear to stand as follows. Commencing at the top:—

SECTION. *Full section in Filey Bay.*		CORRELATIONS. *Already recognised divisions elsewhere.*
1. *A band of Red Clay*	=	*Hessle Clay.*
1A. *Gravels*, with a band of *Dark Boulder Clay*—not continuous	=	*Hessle Gravels.*
2. *Brown Clay*, sometimes very thick		Not before separated.
2A. *Gravels, Sands, and Laminated Clays*—not continuous		
3. *Greenish-Purple Clay*, sometimes very thick	=	*Purple Clay.*
3A. Patches of clean Brown Clay	=	*Laminated Band* at Bridlington.
4. *Blue Clay*, with Shells	=	*Basement Clay.*
5. *Band of Brown Clay*		No known equivalent.
6. *Chalk Rubble*, with Sand containing Shells	=	Similar beds at Danes' Dykes, &c.

With the exception of the bottom band of Brown Clay, these beds have all their representatives in the cliff at Dimlington, south of Withernsea, as the following section, taken near where the cliff is highest at Dimlington, will show. At the top of the cliff:—

Dimlington:—

		Messrs. Wood & Rome's Divisions.
1. Red Clay, with Blue Facings	=	Hessle Clay.
1A. Patches of Gravel	=	Hessle Sands and Gravel.
2. Brown Boulder Clay	=	Purple Clay without Chalk.
3. Boulder Clay, greenish at the top, but changing downwards into a dark purple, with much Chalk	=	Purple Clay with some Chalk.
4. Greenish Blue Clay, with many Shells	=	Basement Clay.

Though in this section the Hessle and Brown Clays alone are divided by sand or gravel beds, still, if either of the other lines of division be followed for a short distance, thick sands make their appearance, and separate the clays most distinctly.

Though Mr. S. V. Wood notices here the peculiarity in what he has termed the Upper part of the Purple Clay, he does not seem to think it was entitled to be considered as of separate age; but it seems to me, that if divisions are made at all in the Yorkshire clays, this must be accepted as one.

In conclusion, it will, perhaps, be of value to briefly recapitulate the evidence on which the divisions of the Drift in Filey Bay here proposed rest.

To begin with the lowest bed:—the bottom Brown Band, with many stones, showed itself on the beach in very decided contrast with the overlying Blue Clay. But as this is at present the only notice of this bed, it would be premature to separate it. By doing so also, we should make the term "Basement," by which the next clay is known, in this case at least, a misnomer. Pending further evidence, it will therefore perhaps be better to class it provisionally with the Basement clay.

Though in Filey Bay the Basement clay, which includes glacial shelly bands both at Bridlington, Dimlington, and here, is only separated from the overlying Boulder clay by an uneven surface, and strongly marked line, along which patches of clay free from stones occur at intervals, at Bridlington this same line is marked by the presence of a very finely laminated, and in some places ripple-marked, clay which has filled up the inequalities of its denuded surface to a depth of 16 feet, just south of Bridlington, as was shown in the workings in connection with the sea-wall now being erected there. At Dimlington, also, the same line is marked by thick sands and laminated clays.

The next clay, which forms the lower part only of the division known as the Purple Clay of Mr. S. V. Wood, is, as I have attempted to show, clearly divided from the overlying Boulder clay, not only by its lithological characters,—for those I put out of the question for the present,—but by the evidence of a denuded surface, which admits into its hollows gravels and laminated clays of great thickness,—in one case a mass of the latter being over thirty feet thick, a deposit which must have required a long time to accumulate.

The Brown Boulder clay, which comes next in succession, is separated from the top Red Band by gravels, more or less continuous, which are in one place at least 30 feet thick, and which sometimes admit into their midst a distinct band of dark Boulder clay, which, though it does not continue far, clearly shows that time must have elapsed between the formation of the one and the other.

In this estimate of the value of these lines of division, I have purposely omitted all reference to the well-marked lithological differences, such as in colour and texture, and in the quantity and character of the included boulders; and to the palæontological distinctions, in the comparative abundance, or rarity, of shell fragments, as effects like these *might* have been caused by changes in the direction or conditions of the ice-flow.

But when these points are taken in conjunction with the presence of the intercalated beds which I have just recapitulated, it seems to me that the sum of evidence thus obtained shows clearly that these beds could not have been accumulated by a continuous and unbroken period of ice-action.

It also shows that there are lines whose claims have been hitherto overlooked, which may be quite as worthily used in dividing these clays as any of those now acknowledged.

It remains to be proved by further research which are the most important of these divisions, but I think it will be found

that the "Basement" and "Purple" clays have their greatest development in Holderness, whilst the "Purple" and "Brown" predominate north of Flambro',—the Hessle capping all.

There is no space within the limits of the present Paper to point out the important bearing of some of these facts on the several theories advanced as to the mode of formation of these clays, but I hope on some future occasion to be able to do so.

THE SOURCE OF THE RIVER AIRE. BY THOMAS TATE, F.G.S.

"Arus ex Pennigenti montibus radicibus ortis." * This was the opinion of the great topographer, Camden, the earliest on record.

Hurtley, the Malham schoolmaster, writing of Malham Water—"a lake embosomed in the cloud-capt mountains"—describes it as "the fountain of the river Air, which, hiding itself, as it were, immediately on its escape from its parent's confines, traverses the bowels and cavities of the earth till it finds a snug and secure retreat amid the almost inaccessible crags at the foot of the Cove." †

The relative claims of the different feeders are fully discussed by Whitaker:—"Speaking in general terms, the lake may fairly be considered as the source of the Aire; but as its outlet quickly sinks into the ground, and is lost, and as several streams which appear below contend for the honour of the connection, it still remains a matter of some uncertainty to which of them the preference is to be given.

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* "Britannia," 1st ed. (1590), page 559. "Leland saith it riseth neere unto Orton in Craven," Harrison (1577) "Description of Britaine." This is mere hearsay, Leland never having visited the district. The quotation is unaccompanied by any reference, and I have not been able to meet with it in the "Itinerary."

† "Natural Curiosities of Malham" (1786), page 34.

The inhabitants of Malham plead that the waters of the Tarn actually appear again in two most abundant and beautiful springs about a quarter of a mile below the village, and nearly three miles from the place of immersion. This opinion seems most probable. But from the foot of the Cove, and almost a mile nearer to the Tarn, a copious stream breaks out, which has undoubtedly the second claim. Yet it is well known that a collection of springs rising in the Black Hills, the Hensetts, and Withes, is swallowed up in a field called the Streets; and from the turbid quality of the water, very unlike that of the Tarn, there is little doubt that, after a subterraneous course of more than two miles, this is the stream which here emerges again. Thirdly, the Aireton Water, from which the village derives its name, seems precluded by its distance from any reasonable pretensions. Fourthly, Gordale Water, which springs in the Great Close, and of which the whole course may be traced, can have no other claim than that of a collateral feeder." *

Phillips says:—"The principal stream of the Aire has a very singular origin. On the limestone hills above Malham is a large piece of water, fed from an immense area of dry rocks which absorb the rain and yield a part of their stores to the elevated lake. Malham Water is on the line of the North Craven fault, overlooked on the north by the limestone ranges of Hard Flask and Fountains Fell, while from below it rises to the south the depressed band of the same limestone. The natural exit of the water is in this direction, as a superficial channel distinctly shews; but instead of following this channel, to fall in a mighty cascade over the tremendous precipice of Malham Cove, the water sinks into the open-jointed limestone rock, and bursts forth in a full and perpetual stream at its foot. This is the Aire." †

* "Craven" (1805), page 206; 3rd ed., page 267.

† "Geology of Yorkshire" (1836), pt. ii., page 162.

Professor Boyd Dawkins figures the Aire as piercing the bed of Malham Tarn, and flowing thence, through a fissure in the limestone, directly to the outlet at the foot of the Cove. *

According to Black's Guide, "its waters have been conclusively ascertained to owe their origin to a small mountain stream in the direction of Cowside." † There are two localities bearing this name, but the area around one drains into the Wharfe, while the area surrounding the other is drained by the Ribble.

Our latest topographical authority gives the following account of the origin of this river:—"The river Aire has its source in several small streams rising in the moorlands at the foot of Fountains Fell and Hard Flask. The principal stream runs from Capon Hall to the Tarn, and is joined by others in its passage. A second feeder, having its origin near Capon Hall, runs in a more southerly direction for about a mile over the 'Streets,' and sinks in a cleft in the rock near an old smelting mill. The stream from Malham Tarn runs half a mile southward, and sinks through a large opening in the limestone. Nothing more is seen of the water until the foot of Malham Cove is reached. The water rushes in a powerful stream from an opening at the base of the Cove, and pursuing a southward course passes through the village of Malham, and half a mile below is joined by the stream from Gordale. The Aire then runs nearly due south through Hanlith and Airton to Bell Busk, where it is joined by the Otterburn." ‡

These conflicting descriptions of the infancy of the river upon whose banks we are met, an appeal to local authority does not tend to harmonise.

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* "Cave Hunting" (1874), page 55, fig. 8.

† "Yorkshire," page 33.

‡ "West Yorkshire," page 327, &c.

One resident writes:—"If you let off the water at the Tarn, you have flooded water at Airehead. The Cove water, doubtless percolating through superior strata, comes from a darker coloured water running over ling-covered lands and peaty beds up at the west of the Tarn, where are the old smelt mills. Any connoisseur in waters could tell the difference speedily enough. A peat water is never so hard and 'petrifying' in its qualities as Mawme Tarn or Airehead springs." The analyses (Appendix B) do not sustain this conclusion, the Cove water being softer (10·8 Clark's scale) than that at the smelt mills (13·1 Clark's scale).

An old inhabitant, speaking at Settle last summer, said:—"We in Malham have always been told that when the Streets Smelt Mills were in operation, and lead washing going on there, the water issuing from the Cove was constantly discoloured." This tradition has been often reported to the writer during the past twenty years. Mr. Morrison, however, has always understood that the scene of the pollution was not the Streets Smelt Mills, but the lead mines on Pike Daw. Mr. Morrison, in answer to our enquiries touching another report, writes:—"Tradition, but not a clear tradition, says that a Lord Ribblesdale tried the experiment, by putting in chaff at the Malham Tarn 'Watersinks,' and that it came out at Airehead." Mr. Leather, C.E., writes as follows:—"I did some work at Malham Tarn for Mr. Morrison some years ago, and I took the opportunity of making some experiments—by holding the water back in the Tarn entirely for a length of time, and then sending down an increased volume for a time—which proved conclusively that the water flowing out from the foot of the rock at the Cove, is not the water which sinks into the ground and disappears some distance above the Cove; the water which so sinks and disappears comes out on the right bank of the stream, some distance below the village of Malham, at Airehead." This test Mr.

Morrison had applied, with the like result, years ago, and had recently repeated, to satisfy Mr. Ruskin, who was then on a visit.

In view of these divergent conclusions respecting the origin of the Aire, a few members of this Society determined to investigate the problem in all its various aspects, by a series of carefully-planned experiments.

The co-operation of Mr. Walter Morrison, the owner of the property, was early sought and promptly rendered; and the success of these researches is due chiefly to his sound advice and practical aid, while his genial conversation and delicate forethought will not soon be forgotten by those who had the good fortune to share his generous hospitality.

Report of the Experiments.

First Day.—Arrived on the ground, the members dispersed to the several points at which it was deemed necessary to keep watch and ward. The temperatures of air and water were recorded at frequent intervals, and samples of the water were collected for subsequent analysis (Appendix A). Wind N.N.E. Although the middle of May, snow fell repeatedly during the day. At 2.30 p.m. a sack of chaff was thrown, or rather thrust, into the "Swallow-hole" at the Streets Smelt Mills, the syke itself being too languid to force the chaff down. At 4 p.m. the sluices of Malham Tarn were opened. Eighteen minutes later the augmented waters of the stream reached the Tarn "watersinks." At 4.25 all the sinks were united and the water rapidly rising; by 4.30 the water was flowing through the top "water-holes" on the wall which separates the stream from the sinks, and the influx of Tarn water caused a rapid fall of temperature. (See Appendix A.) At 4.35 the flow of water had become so great that the sinks were unable to swallow it all; the excess consequently flowed along the old bed of the Aire,

and formed a stream which by a few minutes after five o'clock was fully a hundred and fifty yards long. At 5.25, one hour and twenty-five minutes after leaving the Tarn, the water began to creep over the half-submerged pebbles at Airehead Springs. At 5.50 the depth, at its junction with the Aire, had increased from $8\frac{1}{2}$ inches, at which it had stood all day, to $12\frac{3}{4}$ inches; so that in 25 minutes a stream 4 feet wide had deepened $4\frac{1}{4}$ inches.

The explorers then adjourned for dinner, when it was reported that up to 5.45 p.m. no change had been observed at Malham Cove. On returning to the Cove, however, the scale indicated a rise in the meantime of 2 inches in a stream $31\frac{1}{2}$ feet wide. By the same time the stream at Airehead had risen nearly a foot. No chaff had as yet made its appearance; therefore nets were drawn across the streams at suitable points to intercept any that might be floated out during the night. At 10 p.m. the Tarn sluices were again closed, all but about an inch or so, to keep the fish down stream alive.

Second Day.—Wind N.E. No chaff in any of the nets. The water, both at the Cove and Airehead, had fallen to its normal level. At 11 a.m. an attempt was made to stain the water at the Smelt Mills by the introduction of a quantity of magenta; but a preliminary trial in the open stream was not very promising, all trace of the aniline disappearing in a distance of seven or eight yards. At 11.30 bran was put into all the Tarn "watersinks." A preliminary trial, in this case also, was far from encouraging. At twenty yards the bran was distinctly seen floating in the open stream; at forty yards not a trace could be perceived. It was found to have sunk to the bottom waterlogged. At 1 p.m. the Tarn sluices were again raised, and the liberated water reached the sinks at 1.25, being seven minutes longer than on the previous day. This was owing to the diminished volume of the stream between the Tarn and the sinks. A rise in the water level

at Airehead springs was first perceptible at 2.32 p.m., and by five o'clock it amounted to 13 inches for a breadth of 4 feet. Meanwhile, a similar rise in the level of the water issuing from Malham Cove was being recorded. It was first indicated at 3.10 p.m.; at 3.15 it had risen $\frac{1}{4}$ inch; at 3.20, $\frac{1}{2}$ inch; at 3.35, 1 inch; at 4.5, 2 inches; at 4.45, $2\frac{1}{2}$ inches; and by 5.30 the stream had risen $2\frac{3}{4}$ inches, its outlet being $31\frac{1}{2}$ feet wide.

The weather throughout the day was much finer than on the first day. A snowstorm in the morning, hardly sufficient to wet the boulders, represented all the rainfall, too insignificant to affect the springs.

Third Day.—Stormy, with heavy rain during the morning. The water was permitted to flow freely out of the Tarn during the day, and the high-water level was maintained both at Malham Cove and Airehead. At five o'clock the Tarn sluices were again closed as before.

Fourth Day.—Clear and sunny. The streams at the Cove and Airehead gradually subsided, and by noon the water at the Cove stood $\frac{3}{4}$ of an inch below its normal level. At 5.45 p.m. the water in the Tarn had not quite risen again to the level of the sill of the overflow, so that this sinking of the outflow at the Cove and Airehead confirms the experiment of the rise on the first and second days. Neither chaff nor bran has been seen since it was started on its voyage.

These researches have proved conclusively that the streams issuing at the Cove and at Airehead are both supplied from Malham Tarn by way of the Tarn "Watersinks." They also render it extremely probable that beneath Malham Cove there exists a water-cave, as suggested and figured by Prof. Dawkins, having a wide and somewhat uneven floor. Some such physical conditions are required to account for the delay in the appearance of the flooded waters at the Cove, for although Airehead lies a mile and a quarter further

than the Cove from the "Watersinks," and 117 feet lower, yet the water liberated from the Tarn reached Airehead 38 minutes sooner than it reached Malham Cove. This will be better understood if we observe what occurred above the "Watersinks," in the open stream. On the second day, the waters, having a widespread and shallow channel, required seven minutes longer to travel the comparatively level half mile between the Tarn and the Sinks than they needed on the preceding day, when the channel was practically limited and deeper. In like manner, the difference in contour of the two subterranean passages, connecting respectively the sink which supplies the Cove and the sink whose contents flow to Airehead, will explain the delay in question. A broad but shallow watercourse to the Cove, with a narrow and deep fissure to Airehead, will meet all the requirements of the case.

The theory that Malham Cove is supplied by the stream which disappears at the Streets Smelt Mills is sufficiently refuted by our analyses. It is impossible to believe that water, flowing undiluted through a mile and three quarters of limestone strata, should during its voyage lose between two and three degrees of hardness, as must be the case if these two streams are continuous. The Airehead water (Appendix C) receives surface drainage. Besides, the volume of the Smelt Mills syke is not a twentieth that of the Cove stream.

Pike Daw is still less likely to be the source of the Cove waters. It lies one mile W. 20° S. of the Cove, all the intervening strata dipping to the south, and conducting the drainage off Pike Daw to a lower point in the river.

We may therefore fairly conclude that Malham Tarn, with its feeders draining Fountains Fell, is the natural source of the River Aire. We must not forget, however, that the surrounding area is honeycombed with joints, fissures, or watercourses, ramifying far away to the north where the lime-

stone spreads; and it may well be, after all, that, in the words of Camden, "The Aire has its sources in the roots of Penyghent."

APPENDIX A.

Table of observations made at the different stations.

Temperature of Atmosphere (A) and Water (W).

	Streets Smelt Mills.		Tarn Watersinks.		Malham Cove.		Airehead Springs.		Malham Tarn.	
	A	W	A	W	A	W	A	W	A	W
At	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
11 A.M.	48·5	46·5	48·0	50·0	—	—	—	—	—	—
12 NOON	48·5	48·5	—	—	45·5	48·0	—	—	—	—
1 P.M.	—	—	—	—	43·5	46·5	—	—	42·5	47·5
2 ...	—	—	—	—	—	—	48·5	45·5	—	—
2 30...	50·5	53·0	46·0	53·5	46·5	46·5	44·0	46·0	—	—
3 ...	50·5	53·5	43·5	53·5	—	—	44·0	46·0	—	—
3 30...	—	—	—	—	46·5	48·0	—	—	—	—
4 ...	44·5	52·5	42·0	52·7	45·5	45·5	44·0	46·0	—	—
4 30...	—	—	—	49·0	45·0	46·0	—	—	—	—
5 ...	40·3	50·3	39·3	47·5	45·5	46·0	45·5	46·5	—	—
5 30...	—	—	—	—	43·5	46·0	—	—	—	—
6 ...	—	—	—	—	—	—	47·0	46·5	—	—
Altitude in feet...	1,250		1,220		735		618		1,246	
Distance from the Tarn ...	¾ mile		½ mile		1½ miles		2¾ miles			
Observer in Charge	H. Muller.		A. Crebbin.		J. E. Wilson.		W. G. Tacey.		W. Morrison.	

APPENDIX B.

Analytical results of a partial examination of three samples of water received from Mr. Tate by Mr. F. M. RIMMINGTON, F.C.S., *Analyst for the Borough of Bradford.*

	Contents in grains per gallon.		
	Smelt Mills.	Watersinks.	Malham Cove.
Total Solids	17·9	10·8	14·2
Organic and Volatile Matter	2·3	1·2	2·0
Inorganic	15·6	9·6	12·2
Chlorine	·8	·6	·7
Degrees of Total Hardness...	13·1	9·2	10·8

Appendix C.

Analyses given in the Sixth Report of the Rivers Pollution Commission, 1874, *pages* 43, 11[illegible].

	Tarn.	Cove.	Airehead.
	Contents in grains per gallon.		
Total Solids	8·7 ...	11·3 ...	10·9
Organic Carbon	·19 ...	·2 ...	·11
Organic Nitrogen	·02 ...	·0098 ...	·0049
Chlorine	·66 ...	·8 ...	·69
Total Hardness	9·5 ...	11·2 ...	8·5

NOTE ON AN INTERMITTENT SPRING AT MALHAM.

BY THOMAS TATE, F.G.S.

While prosecuting the investigations recorded in the preceding paper, Mr. Morrison called our attention to an interesting phenomenon, not before publicly recorded. On the north-east of Malham the scar limestone rises abruptly to an altitude of 1,000 feet, forming Cowden Hill. Cowden Hill is ordinarily without a spring, but about once in every five years a body of water rushes out of the foot of the hill and down Finkle Street to the Lister's Arms Inn, with such violence as to tear away the macadam off the road, in parts, down to the rock. This torrential discharge will continue for seven or eight hours, after which the scene will resume its wonted stillness, and the grass reclothe its denuded slopes.

The Sabbatic River of Syria, which, in the time of Josephus, flowed every Sabbath day, but now flows every third day, is an analogous phenomenon. It reminds us also of the "Gypseys" of the Yorkshire Wolds and the "Nailbournes" of Kent. The writer recently accompanied Professor Judd on a visit to Caterham on the North Downs, where is one of these "Nailbournes," which bears a near resemblance to the Cowden spring, inasmuch as it flows once in two years. But the Malham intermittent spring possesses

one peculiarity which distinguishes it from all those just cited. In all siphon springs—for it is to the action of a natural siphon, of course, that the intermittent discharge is to be attributed—in all such springs the flow of water stops suddenly, the moment that the water level in the subterranean reservoir sinks below the inner opening of the siphon-like fissure. But the water which issues from Cowden Hill diminishes in volume gradually, and its flow is not suddenly arrested, as is the case in the other examples given above.

This exceptional behaviour is capable of two explanations: (1) The water may issue from near the base of a deep funnel-shaped natural reservoir, through a siphon whose bend is nearly on a level with its roof, in which case the flow will diminish gradually as the pressure of the superincumbent water is reduced; or (2) there may exist, between the curve of the fissure and the final outlet at the surface, a shallow basin, lodging some portion of the water, which, after the siphon has suddenly ceased to act, may be gradually drained of its contents, thus masking the abruptness of the cessation. There are reasons for believing that the latter proposition represents the conditions under which the Cowden Hill spring is discharged.

NOTES ON THE MIDLAND COALFIELD. BY ARNOLD LUPTON, MEM. INST. C.E., F.G.S. (INSTRUCTOR IN COAL-MINING AT THE YORKSHIRE COLLEGE).

THE Derbyshire Coalfield has been well explored, but the Geological Survey Department has not published maps on a larger scale than an inch to the mile, and, as far as the writer is aware, not of later date than 1855; and the information contained in the memoirs of the survey of this district is by no means as elaborate as that contained in the extremely interesting and valuable book lately published by Professor A. H. Green and the gentlemen of the Geological Department who aided him in his survey of the Yorkshire Coalfield. It

occurred, therefore, to the writer that a few notes on the southern part of the Midland Coalfield might be new to some members of this Society. In the years 1867-8 he surveyed the districts from Nottingham to Eckington, for the Royal Coal Commission. In order to trace the various seams of coal from north to south, some of the best sections obtained from actual sinkings were plotted on a large sheet (which is now shewn). The top hard coal was placed on the datum line in all the sections, and the measurements above and below plotted from that line. The seams which are known, or supposed to correspond, are united by the red lines.

The most remarkable feature in the Midland Coalfield appears to the writer to be the great similarity in the nature of the seams of coal in the north and south. There appears to be a thinning out of the rocks towards the south; but the seams of coal retain the same thickness on the average.

On the western outcrop of the coalfield, seams of coal have been worked which are in the millstone grit series. At Belper Dalley, Alderwasley, possibly at Tansley, near Matlock; at Beeley Moor, and other places near Baslow, and at Ringinglow.

Northward of this place the writer has not examined the millstone grit (on the eastern side of the Pennine Chain) until as far north as Pateley Bridge on the east, and Fountains Fell on the west, is reached. But, according to the information contained in the valuable work of Messrs. Davis and Lees (*West Riding of Yorkshire*), and the geological survey above referred to, coals are found in the millstone grit all the way from Ringinglow to the north of the West Riding.

Thin beds of coal are found in the millstone grit here, and all over the north-west of Yorkshire, and a seam of considerable thickness at Tanfield Moor in the extreme north-west; but not (the writer thinks) thicker than the coal

found in the gritstone at Alderwasley, near Baslow, in Derbyshire.

It might be here remarked that a similar coal has been worked on the Axe Edge, near Buxton, on the western side of the Pennine Chain.

Just above the millstone grit are some coals, called the gannister coals, because the floor of the mine is gannister, and is, or was, used for making fire-bricks. These coals have been worked on the southern outcrop of the coalfield near Stanton-by-Dale; and, going north, at Belper Lawnd, where there were two seams of coal, each from three to four feet thick; they have also been worked near Critch, at Alton, East Moor, and at Totley. Northwards the writer has not traced them; but he understands that these seams correspond to the Halifax Hard and Soft Coals, and are found all along the outcrop of these measures.

Above these comes the Kilburn Coal, a seam celebrated for its purity and excellence as a house coal; fetching in bad times 2s. a ton more than the best ordinary coal in the Derby market. This coal is about four feet thick at Kilburn. Going north and east it thins out. At West Brampton, near Chesterfield, it is only seventeen inches thick; and north of this place it is lost. It is commonly said that the Low Moor beds correspond to this seam of coal. There are several seams of coal above this in the southern part of the coalfield not worked. The Blackshale or Clod Coal comes above this, and is worked continuously from the southern outcrop at Stanton-by-Dale to the northern outcrop of the coalfield, near Leeds. As it comes north it is called the Silkstone Coal at Sheffield; and when it gets near Leeds it gets sub-divided and loses its identity; but the seam of coal retains its principal characteristics throughout the whole coalfield.

To allude to all the seams of coal would occupy a very lengthy memoir; the writer will therefore jump up from

the Blackshale to the Top Hard Coal. This is the most valuable seam of coal. It is the same as the Barnsley bed, and near Nottingham it is a splendid seam of coal, being divided into hard and soft bands, as at Barnsley. It is also a fiery coal in Nottinghamshire, as it is at Barnsley, but being worked in a more scientific manner in the south, no serious explosion has occurred in the Top Hard Coal during the time the writer has known the coalfield.

Between the Top Hard Coal and the Blackshale Coal, and about 120 yards above the latter, is a seam called the Deep Hard Coal. In this coal is a wash fault; it was first found at its south-western outcrop at Denby. There is a broad channel in the coal, about 500 or 600 yards wide, where there is no coal, but where the floor and roof remain. These, however, are uneven, and occupy the place of the coal. Northward, the fault has been traced past Ripley, Brands, Coates Park, Carnfield, and Blackwell, with the same width and characteristics. Beyond the last-named place this seam of coal has not been worked, and, therefore, the length of the wash fault has not been ascertained; it has, however, been traced for eight or nine miles. Wash faults are common in other districts and coalfields, but the writer is not acquainted with any other wash fault at all comparable to this in length and breadth, the coal on each side of the wash fault being precisely the same.

In working the Top Hard seam of coal near Nottingham, gob fires have occurred. The writer attributes them to spontaneous combustion, caused by leaving slack in the mine. These gob fires are also common in working the thick coals in Leicestershire, Warwickshire, South Staffordshire, and have occurred in Lancashire and North Wales. They are not (the writer believes) common in Yorkshire, and he would be glad to know why. Perhaps it is that there is a better market for slack in Yorkshire than in Nottinghamshire, and that, therefore, so much slack is not left in the pit.

OSTRACACANTHUS DILATATUS (GEN. ET SPEC. NOV.), A FOSSIL FISH FROM THE COAL MEASURES SOUTH OF HALIFAX, YORKSHIRE.* BY JAMES W. DAVIS, F.G.S., &c.

THE fossil remains of a fish, which I introduce in this paper, were found in a bed of cannel or stone coal, occurring south-west from Halifax in this county. The coal is extensively wrought, and occupies what appears to have been a number of depressions on the surface of the land during carboniferous times. The beds of coal are found to be thickest in the centre, and, thinning off in every direction, disappear in the course of a few miles. There were probably several of these lagoon-like depressions, and they are known to have extended over twelve to sixteen square miles.† In some cases the coal is found to contain a large number of fossil fish; but this is by no means universally the case. In far the greater majority of the districts worked, the fish remains are extremely rare. I have however obtained from the bed from which this ichthyodorulite was got the remains of both ganoids and sharks, including Megalichthys, Rhizodopsis, Cœlacanthus, and Ctenodus. Spines of Gryracanthus Ctenacanthus, and a series of Pleuracanthus and Orthacanthus, including some new species which demonstrate that the two genera ought to be united and also include with them the teeth Diplodus. Teeth of Helodus and Ctenoptychius, and some others. Labyrinthodont remains are also common. By far the most predominant fish is Cœlacanthus; compared with all the others it is, individually, the most numerous.

The special object to which I wish to draw attention is a very peculiar form of "ichthyodorulite," connected with what appears to be a portion of the exoskeletal plates of a

* Read at British Association, Sheffield, 1879.

† See Prof. Green's *Geology of the Yorkshire Coal Field*, pp. 322-4.

fish. The principal part of the fossil consists of a bony protrusion, or spine, 1·4 inches in length at the longest side preserved. Its breadth at the base is ·5 of an inch. A portion is broken away; when perfect it would probably be ·7 of an inch in diameter. From the base, the diameter diminishes rapidly, and at half an inch from the apex it is ·15 of an inch. This diameter is maintained for ·4 of an inch, and the spine terminates in an obtuse point. Originally circular, the base, more especially, is now compressed to an oval form. The upper part of the spine is smooth and covered with hard ganoine. The lower part is grooved. The grooves are longitudinal, and increase rapidly in number towards the base by bifurcation. The spine appears to be solid; no internal cavity or canal is distinguishable in this specimen. The base of the spine is composed of chondroid bone: *i.e.*, cartilage with numerous osseous centres, but not completely ossified, a similar structure to the bony parts of Pleuracanthus (Diplodus). Extending from the base, there is a mass of similar bony matter. Contiguous to the spine this is produced into two or three short denticles. It then becomes thinner, but again developes into a mass which may very well have served as the base of a second spine, if one were present. There is no evidence, however, of a second spine remaining on the present specimen; it has rather the appearance of a thick scale, somewhat accuminate towards the centre.

Prof. Agassiz, in the "Pois. Foss. des Vieux Grès Rouge," describes the genus *Byssacanthus* with three species, viz., *B. crenulatus*, *B. lœvis*, and *B. arcuatus*. The two former are figured (Table 33, figs. 11 to 14, and fig. 15). The genus is defined as containing spines more or less arched, longitudinally furrowed, with the base much expanded. The spines are about an inch in length and three-quarters of an inch wide at the base. They converge rapidly to an obtuse

point, and are slightly curved; deep grooves extend quite to the point longitudinally along each lateral expansion. In some respects Byssacanthus presents features similar to those of the spine described above. Both are obtusely pointed and much expanded towards the base; but whilst in Byssacanthus the anterior portion of the spine is round and strong, the posterior is much expanded and appears to be thin. In my specimen the basal portion radiates equally in all directions from the point. The furrows on Byssacanthus also indicate this great difference—they lie parallel to the anterior margin from the point to the base on the thicker portion, whilst on the posterior wing-like expansion they are wider apart and spread rapidly towards the base. In my specimen the furrows indicate the homogeneous character of the spine by their similarity in form and arrangement on all sides. There is no further indication that the spine of Byssacanthus was other than the appendage of an ordinary Cestraciont.

This spine, and its attachment to the dermal covering of the fish, bears a strong resemblance to the bony spines of the Trunk-fish, Ostracion cornutus. The Trunk-fish is a small squarely-built fish, protected by a covering of six-sided plates. On its anterior and posterior extremities the dermal covering is produced so as to form four bony spines, broad at the point of insertion, rapidly contracting, and thence continuing to the apex, and ending in a sharp point. The spines of the trunk-fish are long and slender in proportion to their breadth; being fully three times as long as the diameter of the base. The fossil spine is comparatively short, and much stronger, but otherwise they are very similar, both in form and method of attachment.

Hitherto the fishes found in the Coal Measures have been classed as members of one of the two great groups which formed the vertebrate fauna characteristic of the carboni-

ferous age, namely the Elasmobranchii and the Ganoidei. In the genus Ostracacanthus, if the diagnosis I have attempted should be substantiated by further discoveries, there is evidence that fishes closely allied to some of the more abnormal forms of the Teleosteans of the present day existed during that period. Prof. Huxley, in *The Tenth Decade of the Memoirs of the Geological Survey*, has expressed the opinion that several of the fishes of the Devonian rocks are closely related to the modern Siluroids. In the structure of the head of Coccosteus, the general arrangement of the bony exoskeleton much resembles that of the tropical fish Clarias; whilst the peculiar form of the mandibles, and the expansion of the bony elements usually considered to be homologous with the coracoid and radius of other fishes, so as to form a large ventral shield, offers many points of resemblance to the Siluroid, Loricaria. The Devonian Pterichthys is also in several ways closely related with the modern Siluroids. Its osseous envelope can only be compared to the box-like cincture of the modern Ostracion; and the fossil fish Cephalaspis has also certain resemblances to Callichthys and Loricaria. Prof. Huxley remarks that "at any rate I think the *prima facie* case in favour of the Teleostean nature of Coccosteus is so strong that it can no longer be justifiable to rank it among the Ganoids, '*sans phrase*,' but that even those who will not allow it to be a Teleostean must attach to it the warning adjunct of *incerta sedis*." And further, "Why should not a few Teleosteans have represented their order among the predominant Ganoids of the Devonian epoch, just as a few Ganoids remain among the predominant Teleosteans of the present day? When it is considered that an ichthyologist might be acquainted with every fresh-water and marine fish of Europe, Asia, South Africa, South America, the Indian Archipelago, Polynesia and Australia, and yet know of only one Ganoid—the sturgeon—a fish so unlike the

majority of its congeners that a naturalist might be well acquainted with almost all the fossil ganoids and yet not recognise a sturgeon as a member of the group,—it will not seem difficult to admit the existence of a Teleostean among the Devonian ganoids, even though that Teleostean should in some, even important, points differ from those with which we are familiar."

It may be somewhat premature, considering the fragmentary nature of the specimen, to express an opinion that a fish resembling the Teleostean Ostracion has been found in the Coal Measures. The spine and its peculiar attachment, however, are totally different from every other form of icthyodorulite with which I am conversant, and providing the evidence on which Prof. Huxley bases the arguments given above is held to be correctly applied, and that the oldest Devonian fishes have many points of similarity and relationship with the Siluroid family of the Teleosteans, the probability of the occurrence of fishes of a somewhat similar type during the succeeding carboniferous age is rendered at least plausible. I have therefore thought it advisable to bring this peculiar fossil to your notice, not with any wish to dogmatise on its relation to the modern Ostracion, but merely to afford the members of this Society taking an interest in fossil fishes an opportunity of thinking on the subject, and with the hope that some more perfect specimens may soon be discovered which shall place the present one in its true position.

I take the liberty of distinguishing the specimen with the generic name of *Ostracacanthus*,* from the resemblance of the spine to those of the Ostracion, and adding the *nomen triviale, dilatatus,* in reference to its wide and dilated base.

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* Ὄστρακον, a hard shell or testacea, and ακανθα, a thorn.

PLUMPTON ROCKS (SEE PHOTOGRAPH). BY THE EDITOR.

THE subject of the photograph issued with this volume of *Proceedings* has been chosen to illustrate the extensive denudation which has taken place in the upper rock of the Third Grits. The series of Millstone Grits so denominated extend in a semicircular line from southern Yorkshire along the crest of the Pennine chain of hills north-west of Halifax to Plumpton and Brimham. In the northern part the sandstone is decidedly red in colour, and from its uneven hardness is very liable to weather, or become decomposed by the action of atmospheric agencies, into all kinds of peculiar forms. Examples of this action may be seen in several localities, notably at Brimham and Plumpton. At Brimham the justly celebrated Rocks cover a large area, and have assumed a variety of peculiar forms. Fine examples may also be seen on the roadside between Knaresborough and Spofforth. At St. Francis Chapel a large mass of red sandstone stands alone in a field, the surrounding part being disintegrated, and forming the soil. The sandstone is very thick-bedded and massive, it contains a large amount of felspar, the red colour being principally due to iron. It forms a serviceable building stone where of good quality, but it exhibits a tendency in many places to pass into purple sandy shales. The picturesque masses formed by weathering are probably due to this tendency combined with the ease with which the felspar is decomposed. The rocks in Plumpton Park are perhaps the most beautiful example of the effects of this action. They cover a large area, and advantage has been taken of their situation to construct an artificial lake, from the bed of which the rocks rise perpendicularly, as seen in the photograph. Trees also lend their graceful charm to the scene, and afford

shade to the visitor whilst exploring the footpaths ramifying amongst the rocks. A feature showing the soft nature of the rock may be noticed: the rain-water falling on the surface of the rock, in running over its edge has carved little channels along the face of the cliff. These may be seen depicted in the photograph.

SECRETARY'S REPORT.

During the past year very successful meetings have been held at Barnsley and Driffield, the present meeting at Skipton making the third. The Driffield meeting extended over two days, and excursions were made under the guidance of Sir C. Strickland, Bart., and Rev. E. M. Cole, to various points of interest in the wolds. The thanks of the Society are due to those gentlemen, as well as to Messrs. G. J. and A. R. Kell, who assisted materially in the success of the meeting at Barnsley, for their services.

The number of members continues to steadily increase; 22 having been added during the year, the number now on our books is 207. Last year the number was 188. At the annual meeting in 1876, the number was 115.

Four gentlemen have accepted the office of Vice-President, viz., Lord F. Cavendish, Sir C. W. Strickland, Bart., Thos. Shaw, Esq., J.P., Deputy-Lieut. for the West Riding, and W. Morrison, and we regret to state that Jno. Waterhouse, Esq., F.R.S., who has long been a Vice-President, has been removed from that office by death.

The Council are very desirous to extend the work of the Society in the North Riding. Hitherto little has been done in that direction, but it is hoped that a meeting may be arranged at some town in the northern part of the county during next year. The marked success attending the Society's meetings in the Eastern Division of the county lead us to hope that a similar response may be made in the north.

The success of the Society depends to a much larger extent than may be imagined on the exertions of gentlemen who have accepted the office of Local Secretary in various

towns and districts. They are possessed of local knowledge, which is of the greatest value in arranging the meetings of the Society in their respective districts; inducing persons of geological proclivities to join the Society; in keeping alive an interest in geological research, and in many other ways the Local Secretary has important duties to perform; and it must afford satisfaction to know that in all instances these gentlemen have a due appreciation of the importance of their office, and, by their exertions to advance the true interests of the Society, render valuable aid. It is with pleasure that we append the present List of Local Secretaries, remarking that during the past year three have been added, viz., Mr. R. Gascoigne, for Mexbro,' Rev. E. Maule Cole, M.A., for Driffield, and J. E. Bedford, for Leeds..

Barnsley	Thos. Lister.
Bradford	Thos. Tate.
Bridlington	G. W. Lamplugh.
Brighouse	T. W. Helliwell.
Driffield	Rev. E. Maule Cole, M.A.
Goole	H. F. Parsons, M.D., &c., &c.
Halifax	William Cash, F.G.S.
Leeds	J. E. Bedford.
Mexbro'	Rowland Gascoigne.
Ripon...	Rev. J. Stanley Tute, B.A.
Selby	J. T. Atkinson, F.G.S.
Sowerby Bridge	Jno. Marshall.
Thirsk	Ed. Gregson.

It is with much regret that the death is recorded of two of our members during the past year: James Farrer, of Ingleborough House, Clapham, and John Waterhouse, F.R.S., of Halifax, gentlemen well known in the scientific world, who have contributed papers to our proceedings, and who have for many years been staunch friends of our Society.

The following Societies at home and abroad exchange their proceedings and transactions for those of our Society. The volumes are accessible to members on application to Mr. Crowther, The Museum, Park Row, Leeds.

List of Societies whose Proceedings are forwarded to the Yorkshire Geological and Polytechnic Society:—

Yorkshire Archæological and Topographical Society.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania.
Royal Dublin Society.
Royal Historical and Archæological Association of Ireland.
Geologists' Association.
Manchester Geological Society.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
United States Geological Survey of the Territories.
Boston Society of Natural History.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway.
Société-Geologique du Nord.
Oversigt over det Kongelige Danske Videnskabernes Selskabs. Kjopenhavn.

Copies of the Proceedings of the Society for the following years may be had on application to Mr. Crowther, the Assistant Secretary, at The Museum, Park Row, Leeds, price 2s. 6d. each:—1840, 1841, 1842, 1843, 1844-5, 1845-6, 1847, 1848, 1851, 1853, 1854-5, 1858-9, 1860, 1862, 1864-5, 1865-6, 1867, 1868, 1869, 1870, 1871, 1875, 1876, 1877.

MINUTES AND BALANCE SHEET.

Meeting of the Council at the Philosophical Hall, Leeds, March 19th, 1879.

Mr. W. Sykes Ward in the chair. Present—Messrs. Ward, Davis, and Lister.

The Hon. Secretary read the minutes of last meeting, which were confirmed.

Moved by the Hon. Secretary, seconded by Mr. Lister, and carried—"That the following accounts be paid:—Messrs. M'Corquodale & Co., 18s. 3d.; Mr. Ed. Wormald, £19 2s. 6d."

Moved by Mr. Ward, seconded by Mr. Lister, and carried—"That £6 4s., the amount of expenses incurred by the Hon. Secretary, be paid."

Moved by the Hon. Secretary, seconded by Mr. Lister, and carried—"That the next meeting be at Barnsley, on April 9th; and that Papers be read by Messrs. Cash, Seal, A. R. Kell, and Dr. Parsons."

Meeting of the Society at Barnsley, on Wednesday, April 9th, 1879.

The members and friends met at Barnsley at noon, and drove to the Barrow Colliery, Worsbro' Park, the property of the Barrow Hèmatite Steel Company, Limited. They were met by Messrs. Kell, the Engineers to the Company, who had made the necessary arrangements for an early descent; and the members being divided into two groups, one under the guidance of the manager, Mr. C. Beevers, the other that of the deputy, Mr. J. Roebuck, an examination of the workings was made. These are especially interesting since the Silkstone Coal has been won below the Barnsley bed. The depth of the mine is 469 yards.

The afternoon meeting was held at 3 P.M., at the Queen Hotel.

The chair was occupied by W. S. Stanhope, Esq., M.P., vice-president.

The Hon. Secretary read the minutes of the general meeting, held at Wakefield, on October 23rd, 1878, which were adopted.

Moved by Mr. S. Seal, seconded by Mr. Embleton, and carried—"That Captain Bury, of Barnsley, be elected a member."

Moved by the Hon. Secretary, seconded by Mr. Carter, and carried—"That Messrs. J. R. Dakyns, of Bridlington, and Rowland Gascoigne, of Denaby Collieries, be elected members."

Moved by Mr. S. Seal, seconded by Mr. J. Hutchinson, and carried—"That Mr. Newman Crossley, of Barnsley, be elected a member."

Moved by Mr. T. Lister, seconded by Mr. J. Hutchinson, and carried—"That Messrs. Walter Norton, Denby Dale, and John Broadhead, of St. John's Colliery, Normanton, be elected members."

Moved by the Hon. Secretary, seconded by Mr. S. Seal, and carried—"That Mr. Rowland Gascoigne be appointed a Local Secretary for Mexbro' district."

The CHAIRMAN addressed the meeting as follows:—He was very glad to meet so many members of the Society, and to have the honour of presiding on that occasion. He regretted, however, that the weather had not been very favourable, but he hoped that those who had an opportunity of going down the new pit at Worsborough and seeing the Silkstone seam where it was worked below the Barnsley seam, had every facility afforded in their visit. He was very sorry he had not been able to accompany them, owing to having been engaged in county business at Wakefield all the morning. In opening the meeting, it was not necessary for him to make a lengthy address. There were to be Papers on four different subjects, and possibly some gentlemen would desire to ask questions upon them. It was quite unnecessary that he should dilate on the importance of maintaining the status of the Yorkshire Geological and Polytechnic Society. There was perhaps no other county in England that presented more varied sections of all the geological strata, from the chalk on the east down to the Silurian strata, and down to the older strata, which they generally got over before reaching the anticlinal which dipped into Lancashire. And then there was the commercial importance of all this mineral wealth of Yorkshire—the coalfields, the ironfields, the noted flag-measures, besides other kinds of stone and lime—which would take too long a time to enumerate, but which, as it were, bound together the commercial and mining interests with geological research. No doubt many of the discoveries of geologists were more of a theoretical character, and were chiefly interesting as records of the way in which this world had been prepared through countless ages by a merciful Creator for the use of those who now inhabited it; and

though it was not directly the object of geologists to promote the more practical commercial interests of the country, still the two were inevitably bound together. They could well remember the time when very little was known of the classification of the coal-beds of Yorkshire in the different places in which they occurred, and when the coalfields in Yorkshire were supposed to be much more limited than they had proved themselves to be. It was supposed that the Barnsley bed did not extend to Woolley Edge, and it was supposed that there was a very great break between the Wakefield coalfields and those in the immediate neighbourhood of Barnsley. A large and vast amount of country which had been supposed to be barren, had now been proved to be rich in mineral products. It was, in fact, only recently that it was supposed that the Silkstone coal could be found in its entirety and in workable condition below the Barnsley bed. Now they had before them the important problem as to the manner in which the dip itself continued as they went to the eastward. That was a point of immense commercial interest to the neighbourhood. It was very important also to consider whether the Yorkshire coalfields lay in a basin, and rose again to the point where they had been eroded and covered by other strata which had been deposited at a later period, or whether the dip found in the neighbourhood so continued to the eastward, and so more rapidly brought the coalfield to a depth at which it could probably be no longer worked with any prospect of success.

The following Papers were read:—

A. R. Kell, Esq., "On a Section at the Barrow Collieries, Worsbro'." Messrs. Carter, Davis, and the Chairman took part in the discussion.

Stephen Seal, Esq., "On Geological Specimens found in Earl Fitzwilliam's quarry, at Darfield."

Dr. Parsons, F.G.S., "On the Trias of the Vale of York." The Chairman and Hon. Secretary took part in a discussion on this Paper.

J. W. Davis, Esq., F.G.S., F.L.S., &c., "On the Source of the Erratic Boulders, in the Valley of the Calder."

Moved by Mr. Embleton, seconded by Mr. J. Hutchinson, and carried—"That a vote of thanks be given to the readers of Papers."

Moved by the Hon. Secretary, seconded by Mr. T. Lister, and carried—"That a vote of thanks be given to Messrs. Kell for their assiduous attention to the comfort of the members,

and to the Proprietors of the Barrow Hematite Steel Company, for their kindness in granting permission to visit their pit."

Moved by Dr. Parsons, seconded by Mr. S. Seal, and carried—"That a cordial vote of thanks be given to the Chairman for presiding."

At the Dinner, which followed, Mr. Stanhope again occupied the chair, and proposed—"Success to the Society," to which the Hon. Secretary responded.

Meeting of the Council at the Philosophical Hall, Leeds, May 21st, 1879.

Mr. John Brigg in the chair. Present—Messrs. Brigg, Davis, Atkinson, Tate, and Dr. Parsons.

The Hon. Secretary read the minutes of last meeting, which were confirmed.

After reading a letter from the Rev. E. Maule Cole, M.A., descriptive of the arrangements to be made for the summer excursion of the Society, to the Yorkshire Wolds, it was moved by Mr. Atkinson, seconded by Mr. Tate, and carried—"That the next excursion be from North Grimston to Driffield.

Meeting of the Society at Driffield, on Wednesday and Thursday, July 2nd and 3rd, 1879.

This year the Society had a two days' summer excursion. Alighting at North Grimston Station, the members were entertained to luncheon by Sir Charles W. Strickland, Bart., who, together with the Rev. E. Maule Cole, M.A., and Mr. J. R. Mortimer, F.G.S., acted as guides throughout the day. Whilst at Grimston, a visit was paid to the Oolitic Quarries, where Sir Charles Strickland explained the geological features of the country to those present. Wharram Percy was next visited, and specimens of Septarian iron ore obtained. After a visit to Burdale Tunnel, a circuit was made to view Deep Dale, one of the most characteristic of the dales, showing its origin, development, and end within a singularly short distance. From thence to Burdale Station, Thixendale, where train was taken to Driffield. At Driffield, a visit was paid to the museum of Mr. J. R. Mortimer, F.G.S.,

which is particularly rich in human remains and celts obtained from tumuli in the district, and also contains a good collection of Ammonites and Inocerami from the chalk.

On adjourning, the party dined at the Bell Hotel, after which the meeting was held.

The chair was occupied by Sir CHARLES W. STRICKLAND, Bart.

The Hon. Secretary read the minutes of the last meeting, held at Barnsley on April 9th, which were adopted.

Moved by the Hon. Secretary, seconded by Mr. Mortimer, and carried—"That Messrs. R. Thompson, York; Geoffrey Dent, Selby; W. Cheetham, Horsforth; Thos. Singleton, Great Givendale, Pocklington; and C. W. Bartholomew, Blakesley Hall, near Towcester, be elected members."

Moved by the Hon. Secretary, seconded by Mr. Scarborough, and carried—"That Sir Charles Strickland, Bart., be elected a member of this Society."

Moved by Mr. S. Seal, seconded by Mr. Newman Crossley, and carried—"That Mr. Chas. Walker, Houghton Main Colliery, Barnsley, be elected a member."

Moved by the Rev. Mr. Cole, seconded by Sir Chas. Strickland, and carried—"That the Rev. D. Fish, M.A., of Huttons Ambo, be elected a member."

Moved by the Hon. Secretary, seconded by Mr. Scarborough, and carried—"That Sir C. W. Strickland be one of the Vice-Presidents of the Society, and that Mr. Thomas Shaw, of Halifax, Deputy-Lieut. of the West Riding, be a Vice-President, in lieu of Mr. John Waterhouse, F.R.S., deceased."

Moved by the Hon. Secretary, seconded by Mr. Seal, and carried—"That the Rev. E. Maule Cole, M.A., be the Local Secretary for Driffield."

The Chairman addressed the meeting.

The following Papers were read :—

The Rev. E. M. Cole, M.A., "On the Origin of the Dales."

W. Cash, F.G.S., and Thos. Hick, B.A., B.Sc., "On Fossil Fungi from the Lower Coal Measures." (In the absence of the authors the Hon. Secretary gave an abstract.)

J. R. Dakyns, M.A., of H.M. Geological Survey, "Notes on the Bridlington and Sewerby Gravels."

G. W. Lamplugh, "Notes on the Glacial Beds in Filey Bay."

An animated and interesting discussion took place on the points raised by the several papers.

On Thursday, the second day of the excursion, the members took train from Driffield to Wetwang, where wagon arrangements had been made by Mr. Wilberfoss, of Wetwang, for their conveyance to Huggate, a distance of four and a-half miles. There, under the guidance of the Rev. E. Maule Cole, M.A., and Mr. J. R. Mortimer, of Driffield, Huggate Dykes and Millington Dale were visited, and the scenery of these and other extensive dales, marvellous in their development and striking in their effect, were as thoroughly enjoyed as on the previous day. At the Dykes luncheon was provided by the Rev. G. P. Keogh, M.A., who, in responding to the vote of thanks for his kindness, expressed a hope that members of the Association would on their return tell their West Yorkshire friends, in the words of Scripture, that "the barbarous people showed us no little kindness." After an examination of the red chalk at Millington Springs, the party proceeded to Warter, where some extensive views of the Plain of York were obtained. A short stay of an hospitable nature took place here, and then a well-exposed section of red chalk and lias was visited in Warter brickyard. From hence the members walked to Pocklington.

Meeting of the Council at the Philosophical Hall, Leeds, August 27th, 1879.

Mr. J. W. Davis in the chair.

The Assistant-Secretary read the minutes of last meeting, which were confirmed.

It was agreed "That the next meeting be held at Skipton, on September 10th, that Lord Frederick Cavendish, M.P., be requested to take the chair, and that Papers be read by Prof. Miall, Messrs. Eddy, Tate, Lupton, and Davis."

The thanks of the Society are due, and are hereby given to Miss French and Messrs. Greenshaw and Riccall, of Warter, for their kind assistance on the occasion of the visit of the Society, and also to the Rev. Mr. Chilman, of Wharram.

Annual Meeting at Skipton.

The members met at Cononley at 1 P.M., and walked to Raygill Quarries. The Cononley Lead Mines were visited, under the guidance of J. Ray Eddy, Esq., F.G.S., who explained the method of mining, and also of obtaining the lead from the ore.

With the kind permission of Mr. P. W. Spencer, the owner, the members had an opportunity of inspecting the quarries, and also a fissure from which bones of *Elephas antiquus*, Rhinoceros, Bison, Bear, Hyæna, &c., were obtained.

Luncheon was provided by the Treasurer, Jno. Brigg, Esq., J.P., of Keighley, at Raygill.

Prof. Miall gave an address on "The Cave and its Contents," to which a large number of non-members were admitted (about 250):

He said that it was now five or six years since attention was first called to the discovery, and very soon afterwards he and Mr. Tiddeman, of the Geological Survey, came down, and by the kindness of the Messrs. Spencer, the proprietors of the quarries, they were enabled to see what was then going on. At that time the fissure had only been exposed, and that part near to the surface of the ground was being examined. The excavation of the face of the rock since then had exposed more and more of the fissure, and the bones had been found from time to time. They were greatly indebted to the Messrs. Spencer for the care they had taken to preserve what was so interesting. Too commonly, when finds of that kind were made, the things found were pitched into a corner. These remains, however, were to be preserved in the Leeds Museum, where a number were already treasured up, and they would be accessible to all who were interested in the subject. He would first refer to the circumstances under which the bones were discovered. They were found in a fissure which originally communicated with the surface, and which evidently penetrated a considerable depth into the rock. No doubt, when they came into their present situation, the fissure was, as he had first intimated, open, and communicated with the air. How they got into the fissure he did not know: probably they fell in, or were washed in. The chief interest relating to the collection was the nature of the material which sealed them up, viz., clay, some of which was very stiff and some exceedingly loose, and what might be called rain-wash. In this clay there were local pebbles, such as limestone, and pebbles which had come from distant parts of the county. When he and Mr. Tiddeman visited the quarry, they discovered some pebbles of greenstone, and a large piece of slate. Amongst the bones were several of an elephant, and the elephant was of a species not now found in any part of the world. In some respects it was intermediate between the African and Indian elephants. The plates of the molar teeth were closer than the African, and not so close as the Indian. It was known as the *Elephas antiquus*. Besides the teeth, there were some of the bones of the limbs. Next they found some fine teeth of a rhinoceros, also of an extinct species (*Rhinoceros leptorhinus*). There was also an exceedingly fine

canine tooth of the bear, and some other specimens of the same animal. Of the bison, teeth and other remains occur. Then there were remains of a hyæna, apparently of the same species as the Cape hyæna, which had occurred frequently in cave deposits, as well as tusks of the hippopotamus. The bison was the same as was to be found in North America. The hippopotamus, such as was found in rivers of Africa. The hyæna at the Cape, as he had said, and the bear in many parts of the northern hemisphere. The special points of interest appeared to him to be these:—That there occurred remains of extinct animals; and, secondly, that there was an entire absence of what might be called northern or arctic forms. In Cresswell Crags and Windy Knoll, in Derbyshire, the animal remains were those of existing forms only; but these bones represented animals of the southern type, and belonged to an earlier state of things than those under which most of the caves of England received the bones of fossil animals. Referring to the circumstances under which the bones got into the fissure, he said that whether they fell in, or were washed in, they naturally fell towards the bottom of the fissure, and the clay accumulated which sealed them up. But before the clay accumulated the circumstances of the country had changed, the severe cold which marked the glacial epoch of the geologist had begun to be felt, and a considerable portion of the clay in the fissure was evidently glacial—including the far-travelled pebbles, transported by moving land ice. In a climate considerably colder than the present, the caves of Cresswell Crags, and other parts of Derbyshire, were filled, and there they found the remains of arctic animals side by side with some of the southern forms, such as were discovered at Raygill. The remains of the species found at Raygill—which were no doubt at one time plentiful throughout the district—appeared to have been swept away from the surface of the open country by the ice-sheet which seemed to have extended southwards as far as Leeds. For a collection of remains, similar to those preserved in the fissure, they had to go to the valley of the river Aire, near Leeds, where, in a brickfield, were found the bones of the elephant, rhinoceros, hippopotamus, and bison. The whole story of the Raygill Quarries deserved to be told at full length, and he hoped before long to be able to lay the facts of the discovery before the Geological Society. The occurrence of the remains he had referred to, under such singular circumstances, required some permanent record to be made. In conclusion, Professor Miall expressed the thanks of the Society to the Messrs. Spencer and their foreman, for the care they had taken to preserve these most interesting relics.

The members walked from Raygill to Skipton, and dined at the Devonshire Arms.

At the Annual Meeting, held at the Devonshire Arms, Skipton, a letter was read from Lord F. Cavendish, M.P., stating that his lordship was unable to be present, being prevented by illness.

Walter Morrison, Esq., of Malham Tarn, was requested to preside, and kindly consented.

The Secretary read the Annual Report of the Committee.

The Treasurer read the Balance Sheet.

The Chairman proposed their adoption, and gave an address.

Proposed by Mr. Davis, seconded by Mr. Stott—"That the following gentlemen be elected members of the Society: Lord F. Cavendish, W. Morrison, J. Ray Eddy, J. B. Dewhurst, Wm. C. Slingsby, Ed. Drury, J. M. Barbour, and W. Emmott." Carried unanimously.

On the motion of Mr. Davis, seconded by Mr. Tate, the Marquis of Ripon was re-elected President.

Proposed by Mr. Brigg, seconded by Professor Miall—"That the Vice-Presidents be re-elected, with the addition of Lord F. Cavendish, M.P., and Walter Morrison, J.P." Carried.

Proposed by Mr. Stott, seconded by Mr. Barber—"That the Secretary and Treasurer be re-elected." Carried.

Proposed by Mr. Tate, seconded by Mr. Bird—"That the Committee be re-elected." Carried.

The following are the Council:—

President.

The Most Hon. the Marquess of Ripon, K.G., F.R.S., &c.

Vice-Presidents.

His Grace The Duke of Leeds.
His Grace The Duke of Norfolk.
The Right Hon. Earl Fitzwilliam.
The Right Hon. Earl of Effingham.
The Right Hon. Earl of Wharncliffe.
The Right Hon. Earl of Dartmouth.
The Right Hon. Lord Londesborough.
The Right Hon. Lord Houghton.
The Right Hon. Viscount Galway.
The Right Hon. Viscount Halifax.
The Right Hon. Lord Frederick Chas. Cavendish, M.P.
Sir C. W. Strickland, Bart.
W. B. Denison, Esq., M.P.

W. T. W. S. Stanhope, Esq., M.P.
Edward Akroyd, Esq., F.S.A., &c.
Thos. Shaw, J.P., Deputy-Lieutenant of West Riding.
Walter Morrison, Esq.

TREASURER.

John Brigg, J.P., F.G.S.

HON. SECRETARY.

J. W. Davis, F.S.A., F.G.S.

COMMITTEE.

Wm. Alexander, M.D., J.P.
Fairless Barber, F.S.A.
R. Carter, C.E., F.G.S.
T. W. Embleton, C.E.
E. Filliter, C.E., F.G.S.
Prof. A. H. Green, M.A., F.G.S.
H. P. Holt, C.E., F.G.S.
Prof. L. C. Miall, F.G.S.
R. Reynolds, F.C.S.
H. C. Sorby, LL.D., F.R.S.
T. W. Tew, J.P.
W. Sykes Ward, F.C.S.

Proposed by Mr. Davis, seconded by Mr. Lupton—"That the following addition be made to Rule VI.:—'That members may compound for their annual subscriptions, and become life-members on payment of six guineas.'" Carried unanimously.

The following Papers were read:—

J. Ray Eddy, Esq., F.G.S., "On Lead Veins, in the Millstone Grits, near Skipton."

Thos. Tate, Esq., F.G.S., "On the Source of the River Aire."

Arnold Lupton, Esq., C.E., F.G.S., &c., "Notes on the Midland Coalfield."

Jas. W. Davis, Esq., F.G.S., &c., "On Ostracocanthus dilatatus (Davis), a new genus of Fossil Fish, from the West Riding Coal Measures."

Discussions after each Paper were partaken in by the Chairman, Messrs. Lupton, Davis, Brigg, Eddy, Dewhurst, Tate, and others.

A vote of thanks to the Chairman, on the motion of Mr. W. C. Barber, seconded by Mr. Bird, concluded the proceedings.

Statement of Receipts and Expenditure of the Yorkshire Geological and Polytechnic Society,

FROM OCTOBER 1ST, 1878, TO SEPTEMBER 30TH, 1879.

Dr. *The Treasurer in Account with the Yorkshire Geological and Polytechnic Society.* **Cr.**

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance	3	0	7½	By Cash Paid into the Bank	68	19	0
„ Subscriptions	79	6	0	„ Stationery and Printing, including two Annual Reports	78	5	6
„ Beckett and Co.	114	8	3	„ Postage and Carriage	5	16	4
„ Reports, &c., sold	3	12	6	„ Cost of Photographs	24	3	9
				„ Expenses	9	11	3
				„ Salary of Assistant-Secretary (eight months, to May 31st, 1879)	10	0	0
				„ Balance in Hand	3	11	6½
	£200	7	4½		£200	7	4½

Dr. *The Treasurer in Account with Beckett & Co.* **Cr.**

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance at Bank	69	3	7	By Cash from Bank	114	8	3
„ Cash Paid to Bank	68	19	0	„ Cheque Book	0	5	0
„ Interest	1	7	3	„ Balance in Bank	24	16	7
	£139	9	10		£139	9	10

Audited and found correct, *September 10th*, 1879,

L. C. MIALL.

Summary of Geological Literature relating to Yorkshire, published during 1877 and 1878.

Compiled by James W. Davis.

1877.—ADDENDA.

Anon. A New Coal Field (Barnsley Coal at Monckton Main). *Coll. Guard.*, vol. xxxiv., p. 738.

Curry, J. Is there a Base to the Carboniferous Rocks in Teesdale? *Geol. Mag.*, dec. ii., vol. iv., pp. 138-139.

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——— On a Deep Boring for Coal, at Scarles, Lincolnshire, and its bearing on the question on the Easterly Limit of the Yorkshire Coal-measures beneath the Newer Formation. *Proc. Inst. Civ. Eng.*, vol. xlix., p. 160, pl. 4 (geological map); *Rep. Brit. Assoc. for* 1876, sections, pp. 91-92; *London Iron Trade Exchange*, vol. xxi., p. 136.

Reed, W. An Artesian Well at Masham, in the North Riding. *Ann. Rep. Yorks. Phil. Soc. for* 1876, pp. 29-35.

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Tiddeman. R. H. Fourth Report of the Committee appointed for the purpose of assisting in the Exploration of the Settle Cave (Victoria Cave). *Rep. Brit. Assoc. for* 1876, pp. 115-118.

1878.

Aveline, W. T., Prof. **A. H. Green**, **J. C. Ward**, **R. Russell**, and **T. V. Holmes.** Sheet 87. South-West of the Geological Survey of England and Wales.

Brooke, Thos. Address at Huddersfield. *Proc. Geol. and Polyt. Soc. of West Riding*, new series, pt. iv., p. 253.

Cash, Wm. Notes on Carboniferous Cephalopoda; pt. i. Recent Cephalopoda. *Ibid.* p. 257.

Dakyns, J. R. On a Base to the Carboniferous Rocks in Teesdale. *Ibid.* p. 239.

——— and **W. H. Dalton.** Sheets 98 (Litton) and 115 (Arncliffe) of the Geological Survey Map of Yorkshire. (Six inches to a mile.)

——— and **J. Lucas.** Sheet 116 of the Geological Survey of Yorkshire. (Six inches to a mile.)

——— **J. C. Ward**, **C. F. Strangways**, and **W. H. Dalton.** Sheet 215 (Denholme) of the Geological Survey Map of Yorkshire. (Six inches to a mile.)

Dakyns, J. R., C. F. Strangways and **W. H. Dalton.** Sheet 200 (Keighley) of the Geological Survey Map of Yorkshire. (Six inches to a mile.)

——— and **C. F. Strangways.** Sheet 185 (Kildwick) of the Geological Survey Map of Yorkshire. (Six inches to a mile.)

Davis, James W. On the Unconformability of the Permian Limestone to the Red Rocks West of its Escarpment in Central Yorkshire. *Proc. Geol. and Polyt. Soc. of West Riding of Yorkshire*, new series, pt. iv., p. 280.

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——— and **F. A. Lees.** West Yorkshire: an account of its Geology, Physical Geography, and Botany. Maps and plates; pp. xi.-414. 8vo., London.

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——— **R. Russell, J. R. Dakyns, J. C. Ward, C. F. Strangways, W. H. Dalton,** and **T. V. Holmes.** The Geology of the Yorkshire Coal Fields. *Geol. Survey Memoir*, pp. xiii.-824; 26 plates. 8vo., London.

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Ward, J. C., J. Lucas, and **R. Russell.** Sheet 202 of the Geological Survey Map of Yorkshire. (Six inches to a mile.)

*** The compiler has much pleasure in acknowledging the kind assistance received from the Editors of the *Geological Record*, who have placed their advanced sheets and MS. at his disposal. Thanks are especially due to W. H. Dalton, Esq., of H.M. Geological Survey.

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*** It is requested that Members changing their residence will communicate with the Secretary.

PROCEEDINGS

OF THE

YORKSHIRE GEOLOGICAL AND POLYTECHNIC SOCIETY.

New Series.—Vol. VII., Part III., pp. 221 to 329.

With Three Plates.

Edited by JAMES W. DAVIS, F.S.A., F.L.S., F.G.S.

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1880.

ADDRESS ON THE WORK OF SCIENTIFIC SOCIETIES, BY THE MARQUIS OF RIPON, K.G., ETC., PRESIDENT.

The Marquis of Ripon, in opening the proceedings, expressed his sense of the honour conferred upon him at the last meeting, by his re-election to the office of President of the society. He congratulated the members upon the position which the society occupied. He believed he was justified in saying that it had, at no previous period, been in a more flourishing condition. The number of members showed a continual increase; and the value of the papers read before the society from time to time, had at all events been sustained, if it was not improving from year to year. (Applause.) He did not know whether all those who were present were members of the society. The meeting was open to other persons who might honour them with their presence, and in the supposition that there might be some there, or others by whom his words might be afterwards read, who might not be altogether aware of the work which the society was doing, he would allude very briefly to the labours of the society during the past year. They had made visits to three different parts of the county. This society, originally connected exclusively, in its title at all events, with the West Riding, had within the last few years extended the sphere of its operations to the whole county of York, and in accordance with that extension they were now visiting different parts of the county in the various Ridings

Last year they visited Barnsley, in the coalfield of South Yorkshire —a district highly interesting naturally to a society, one of whose main studies was geology. They subsequently visited Driffield, in the neighbourhood of the Yorkshire Wolds, in a district somewhat new to the operations of the society. And finally, they visited Skipton in Craven, where they found subjects very interesting to those who were engaged in the pursuits mainly followed by the members of this society. (Hear, hear.) That brief record of the work done—not to allude to the papers which had been read to the society during the past year, and which were many of them of great interest—that brief record would show them that it was the object of the Yorkshire Geological and Polytechnic Society to investigate the scientific treasures of the county in every part of it, and to bring the benefit and advantage of their discussions and operations within the reach of persons throughout the whole length of the great county to which they belonged. (Applause.) He had said that at their visit to Skipton they were fortunate enough to meet with ground for investigations very interesting to the members of the society. He alluded to the fact that there had been brought under their notice a very interesting fissure in the limestone rock in the Raygill quarries, in the neighbourhood of Skipton, which on examination was found to contain various important and interesting remains of extinct animals. They found the *Elephas antiquas*, an extinct species of elephant, the rhinoceros, bison, hippopotamus, bear and other animals—some of them extinct, and some, at all events, not now found in this country. The last report contained a brief notice of these discoveries, from the pen of one of the ablest members of the society, his friend Professor Miall. (Applause.) He ventured to say that he did not think he should misinterpret Professor Miall's own feelings when he said he hoped, and he was sure the hope was shared by all who had looked at that paper, that that brief statement was not the only record they were to have from him of the results of the investigation. (Applause.) But even that brief statement would show how interesting these inquiries were, because he clearly proved from the facts developed by what

was comparitively a cursory examination of this interesting spot, that there was distinct proof of two perfectly and entirely different periods of the history of the world—a period when there existed in this country a much warmer climate than that which was enjoyed now, when these animals were to be found to which he had alluded; and subsequently a glacial period, when this state of things was altogether changed. He trusted very much that Professor Miall would be good enough to develop these questions in some future paper, which would, he was confident be of great interest to geologists, not only in Yorkshire but throughout the country—(applause)—and in order that he might do that, it was essential that this interesting fissure should be thoroughly examined. (Hear, hear.) The council of the society had issued a little circular pointing out the importance of this examination, and inviting subscriptions for the purpose of defraying the very moderate expenses which would have to be incurred on account of it. He could not for a moment doubt that the necessary funds would be forthcoming, not alone from the resources of the members of the society, but from others in Yorkshire who might be interested in inquiries of this kind. For himself he had been most happy to inform Mr. Davis, their honorary secretary, who worked so hard for the society, with such great advantage to its members—(applause)—he had had the pleasure of telling him that for himself he would be very happy to contribute £10 towards the sum which was required for the purpose—(applause)—and he only hoped, and felt confident that others would very readily supply the means that were necessary for the thorough and complete examination of a locality which was likely to throw considerable light upon many interesting scientific questions. (Hear, hear.) He was very glad to understand that the council of the society were anxious in the course of the present year, to visit some portion of the North Riding of Yorkshire. (Hear, hear.) As he had said, the society had recently extended its operations to the whole county, but he thought that with the single exception of Scarborough, they had not yet visited any portion of the North Riding. He was very glad, therefore, to find that they were contem-

plating to turn their attention this year to that important district, and he ventured to say that they would find much to interest them among the fells and dales of the north-western part of this county, or in the iron district of Cleveland. Whichever place in the North Riding they proposed to visit, he could say that Teesdale, Swaledale, and Wensleydale were all of them well worth exploring They would all prove highly interesting to men of science, and sure he was that they would afford to every member of this society, and to all the friends who might accompany them, very many most picturesque and attractive scenes for those who were lovers of nature. (Applause.) There was another reason which made him, who was a good deal connected with the North Riding, having the honour to be Lord-Lieutenant of the Riding—glad to find that the society contemplated visiting part of the county this year, and that was because they would thereby, as he trusted, give an impulse to the study of science there. It must be borne in mind that the visits of this society to different parts of the county, were not merely intended to benefit the members of the society themselves, but the meetings and excursions being open to others, they were intended to propogate an interest in science and to encourage its study in the districts which they might visit. (Hear, hear.) He might be permitted for a few moments to ask them to consider what were the functions of a society of this kind, and what was the position which it held in the general educational system of the country. When he talked about the position which this society held in the educational system of the country, he might be met with the preliminary objection—"What do you mean by talking about the educational system of this country? We have not got anything in the nature of an educational system at all. It is all left to haphazard, and to individual zeal and local effort, and there is nothing systematic about it." He supposed that that criticism. which was not merely an imagination of his, but which we saw made of our educational system from time to time, arose from those who desired to see established in this country a wide-spread general system of State education—primary, secondary and tertiary—set

up throughout the land, upon a uniform system, aud directed from a central department—(hear, hear)—and who thought that anything that fell short of that was not worthy of the name of a national system of education. He was bound to say that he did not share that view. He did not believe that State interference with education was a good thing in itself. He believed that it was a necessary thing in certain cases—for instance, in primary education. But he said that it was on the whole, undoubtedly desirable to confine it within narrow limits, and to avoid having recourse to the State in these matters, wherever it could be avoided, and especially it seemed to him that this was the true principle in respect to the pursuit of the physical and natural sciences. As they all knew, those physical and natural sciences had been for a long time, and were now, in so constantly progressive a state that it was essential, as he believed, in order to ensure their satisfactory advance, that they should enjoy the utmost possible amount of freedom. Now, the science which a Government could undertake to teach would always be, in a highly progressive state of things, just a little behind the foremost teaching of the day. He had no doubt that any Government department would always desire to place the control of scientific education, if it undertook the duty, in the hands of the most eminent scientific men of the time—that was to say, in the hands of the most eminent scientific men of the time when the appointments of those gentlemen were made. But in a few years—in some cases it might be a much shorter period, or he was much mistaken—the men so appointed would be in many respects passed by younger competitors. Their views would have, before long, become in many respects out of date, and yet no Government who had appointed men of that eminence could venture to remove them. He would not refer—it would be quite unbecoming to do so—to any examples of this kind; but he could not help thinking that some of the scientific gentlemen who were present could put the cap upon heads that it would fit, and must in their recollection know very well that the danger that he had alluded to was not imaginary and might have easily arisen during the last ten or fifteen

years of the scientific history of this country. As it was, they knew very well that the ideas of the younger school had to struggle for acceptance, and had to fight their way not merely against the weight of received opinions, and the authority of great names and the force of accepted reasoning—they had that now, and it was quite right that they should have to encounter that sort of difficulty, and if they had truth upon their side they would encounter it successfully, and would overcome it—but he ventured to submit that it was not advisable that in addition to these necessary difficulties, which growing ideas and new views had always to fight against, they should have also to contend against the all-pervading power of a Government department stamping opinions which were passing away with the *imprimatur* of the State, and disturbing—if he might be pardoned the metaphor—the impartial balances of science by the dead weight of State favour. (Applause.) He believed that this was not an imaginery danger, and he submitted the consideration to those who were dissatisfied with the English system in this respect. In all experimental branches of knowledge the first essential element of progress was freedom—freedom of investigation, freedom of discussion, the honest search for facts, the faithful report of them, and their unprejudiced examination. (Applause.) And if that was at all an accurate description of what was desirable in the progress of science in its physical and natural branches, then he ventured to claim for a society of this kind that it was calculated greatly to promote that end. One of their great objects, one of their main purposes, he took it, was to encourage individual inquiry —(hear, hear)— to collect facts all over the face and surface of this great county, to encourage men in every position and circumstance of life, to help them in their business of collecting facts in these sciences, and to test the truth and reality of the facts so collected, by open and free discussion at the meetings of the society; and then, when they had done that, and had sifted the facts, to pass on those which seemed worthy of further consideration to the great societies of the country, and to the eminent men of science who were the great lights of scientific inquiry of the day, and thus

to help to store up that wide collection of observations upon which alone sound scientific inductions could be based. But however important this portion of their work was, it was not their only function. Their labours were of a two-fold character. They had not only to collect facts and register observations, or even to discuss and examine into their bearings, but they had also a direct function of education, which was that which as it seemed to him, specially entitled it to be said of this society that it had its appropriate place in our system of education. It was their special function to meet young men when they left the Universities, or the higher schools, or Mechanics' Institutes, and to help them to carry on in after life, under their guidance and with their assistance, the studies which they had begun there. It was their business to take these young men, from whatever class of life they might have sprung; to test, and to guide, and to encourage them; to check them where they needed to be checked, and where they seemed to be falling into error—to check them by the only efficient check in inquiries of this description, namely, by free and open discussion, and thus to enable them to apply the teachings which they might have received at any of the higher schools or even at the Universities in the field of actual experiment, and to carry on throughout life, and in the midst of the business engagements of life, not only the cultivation of their own minds, but the advance also, and progress of scientific inquiry in the country. (Applause.) He was strongly impressed with the belief that the just fulfilment of such a function as this was one of great value, not only locally, but to the nation at large. He had not the slightest inclination to institute any kind of invidious comparison between the branches of knowledge relating to those physical and natural sciences with which the society had to do, and to which it was the habit of the day almost to confine—erroneously, as he thought—the name of science, and those other branches of knowledge—philosophy, history, literature, and the like. In the circle of human knowledge—they had each their appropriate place in the adornment of human life, they had each their proper sphere, and they could all be made, if used aright, a fruitful

means of cultivating and developing the human intellect. Individual tastes and personal circumstances must ever determine, to a very great extent, the direction of a man's studies. He was not in the least inclined to quarrel with the special direction which these studies might take in any case. The thing of real importance for the man and for the nation, was, that they should, whatever might be their character, be pursued for high motives and made subservient to noble ends.

ON THE DISTRIBUTION OF FOSSIL FISHES IN THE YORKSHIRE COAL FIELDS. BY JAMES W. DAVIS, F.S.A., F.G.S., ETC.

THE Coal measures of the West Riding of Yorkshire, until recently have received little attention so far as their palœontology is concerned. Their stratigraphical features have been worked out and developed most carefully, not only by private enterprise for commercial and industrial purposes, but also in a more thorough and scientific manner by the officers of the Geological Survey. The Memoir on the Yorkshire Coal field, recently completed by Prof. Green (now of the Yorkshire College) and his associates, will perhaps take rank as the most elaborate and important work issued by the Survey. The value of this intricate and detailed accumulation of facts cannot be over-estimated, and to the practical miner, or the more philosophical geologist or palœontologist, the book must be one of constant use and reference. Already, the workings in this coal field have been extended considerably under the Permian limestone, which in the earlier days of geological science was thought to be its eastern limit, and pits sunk to the depth of over 1,500 feet have proved that the Silkstone coal exists over a large area, where only the Barnsley coal has previously been got. Indeed, the only eastern limit to the Yorkshire coal field will be caused by the great depth at which the coal lies buried. To the north and west the coal field is encircled by the older beds of the Millstone Grit series. The latter, forced up during a post-carboniferous epoch, form the elevated Penine chain of hills which now separates the once-united Yorkshire and Lancashire coal fields.

The millstone grit rocks merge gradually and without any distinct or arbitrary dividing line into the coal measures. The thick-bedded, often coarse, grit rocks with thick intermediate beds of shales give place to finer sandstones and shales, with occasional coal seams in the lower coal measures, and these again to the more rapidly alternating shale and sandstone, and frequently recurring coals of the middle coal measures.

The fossil fishes in the coal measures of Yorkshire hitherto discovered, have been principally from two or three localities. In almost every instance where those remains have been found they are obtained from the shale immediately above a coal bed, and they usually present the same features throughout the whole series. The genera of fish found in the lower coal measures are also found in those higher in the series, but there is not always the same proportion of individuals of any given genus in the same beds. Some genera are of frequent occurrence in the higher beds, whilst in the lower, though still present, they are in much diminished numbers.

The fishes are not often found over large areas, even when a seam of coal, above which they have been found to occur in tolerable abundance in one locality, extends persistently over a large area, it does not follow that the fossil fish will be uniformly distributed over that area. In most instances, on the contrary, the fishes are discovered in certain districts, whilst in others the same bed, on the same horizon, is unproductive. It is worthy of remark, that where fish are found above any given bed of coal, though the situations may be widely separated, there is a close relationship between the fish of the several localities, for example, the Halifax Hard Bed Coal in the neighbourhood of the town from which it derives its name has yielded remains of Megalichthys, Cœlacanthus, Acanthodes, and others. At Baildon, near Leeds, where fish-remains have also been found above this coal, they are generically identical. The specimen which served as the type for Prof. Aqassiz's description of the genus *Cœlacanthus* was obtained from a large nodular mass locally known as a 'baum-pot' above the hard bed coal at Halifax. Fish-remains in the Halifax beds are not common, and

where found are nearly always associated with mollusca of a marine origin, such as Goniatites, Nautilus, Avicula-pecten, and Orthoceras. About 700 feet above the base of the coal measures is the Elland Flagstone, known south of Huddersfield as the Grenoside Rock, and immediately above these flagstones there is a bed of coal, two and a half feet thick, the Better Bed Coal ; it is peculiarly free from sulphur and in consequence is valuable for iron smelting : the excellence of the Low Moor Iron has been attributed in a great measure to the use of this coal. It possesses a further characteristic of interest to students of fossil botany, viz, that in some parts of the seam the coal is made up of the macrospores of fossil plants, so well preserved that the microscope reveals their structure and botanical affinities with much perfection. The most important feature in connection with this coal, for our purposes, is constituted by the presence of a thin stratum of shale immediately above it, which is to a very great extent made up of fish remains. So completely is this the case that I have ventured in the proceedings of the Geological Society of London to describe it as a Bone-bed.* It extends for several square miles, overlying the coal, and is nowhere more than half an inch, generally not more than one quarter of an inch in thickness. From this thin stratum have been obtained nearly forty species of fossil fish and labyrinthodonts. The remains are frequently broken and appear to have been a good deal rolled about before they became finally embedded. They consist of about equal proportions of marine fishes and of those which live in fresh water at the present time.

The next important coal is the Black-bed seam. It is extensively wrought near Bradford and Halifax : in the shale above the coal there is an extensive deposit of Clay-Ironstone, the two being worked together. Many important fossils have been found in the shale near its junction with the coal, and especially a large labyrinthodont, Pholiderpeton scutigerum, named and described by Prof. Huxley. From the Black-bed coal to the Silkstone or Blocking

* Quar. Jour. Geol. Society, vol. xxxii, p. 332, 1876.

coal, which is regarded as the dividing line between the Lower and Middle Coal measures by the Officers of the Geological Survey, there are several important coal seams, but I have not yet succeeded in finding any fish remains in connection with either of them.

The Middle coal measures include all the remaining strata of the Yorkshire Coal field. Three or four beds of coal in these measures have yielded fish remains: the Silkstone coals; the Middleton beds, near Leeds, from which the Agassizian genus Megalichthys was derived, the specimen being now in the Leeds Museum; the Joan coal, and the Cannel or Stone coal, worked at Bruntcliffe, Ardsley, Tingley, and one or two other places. The latter contains a more remarkable series of fossil fish than any other stratum in this district; a detailed description of this coal may be found in the proceedings of the Yorkshire Geological and Polytechnic Society for 1878. It occupies a basin-shaped hollow extending only a few miles, and thinning out in every direction from the centre. Other similar areas,* on the same horizon, are filled with beds of cannel coal, extending south-westwards from Tingley, but in no other instance, so far as I know, do the coals possess so rich a fauna as the one named. The cannel coal is divided into two parts by an intervening bed of black carbonaceous shale; at its base is a bed of ordinary coal, and above it a shale filled with ironstone nodules,—both the shale and ironstone contain immense numbers of shells of Unios or Anthracosia, as well as a large series of plants. The fossil fish preserved in this coal are found in greatest abundance at the junction of the cannel coal with the intermediate shale, but they are also scattered somewhat indiscriminately throughout the coal.

Having thus briefly summarized the various strata in the West Riding, from which fish remains have been obtained, I purpose to consider the several characteristics of the fossils and their relations to existing species, so far as they can be made out.

* See "Geology of the Yorkshire Coal Field," by Prof. Green and other Members of the Geological Survey, 1879

The fish of the coal measures have been hitherto regarded as belonging to either the Elasmobranchs or the Ganoids. In recent sharks the whole of the framework of the body is frequently cartilaginous: the vertebræ, the brain-case, and jaws are all composed of cartilage. The teeth, the dermal tubercles or shagreen, and, when present, the spines protecting the dorsal or pectoral fins, are the only parts of the fish which are composed of bone, and, as would naturally be inferred, they are the only parts of these fish which are found fossil, all the remaining cartilaginous and soft parts have been decomposed and lost. Nor is this the only difficulty, the cartilaginous framework which held the teeth and spines together being removed, the latter became separated, and now there are few instances where the teeth and other fossil parts of the fish can be correlated. It is an extremely rare occurrence to find the spines, teeth, or dermal shagreen in such relationship with each other, that it can be clearly demonstrated that they belong to the same species, or even the same genus of fish. The organs on which modern classification is based, viz.—the dilated aorta or *bulbus arteriosus*, with its variable series of valvular openings; the non-decussating optic nerves; the spiral valve in the intestine, all serve to distinguish the sharks and the ganoids from other fishes at present existing. In the fossil fish of the coal measures, the heart, brain, and intestines have now no existence, and we can only reason by analogy, that as in recent fish we find certain functional relations existing between the soft and hard parts of the fishes, so in the fossils, having found the hard bony parts preserved, and these exhibiting certain close relationships with the recent forms, it is inferred that the soft and decayed portion of the fish have also borne a similar relationship to the recent forms.

The Ganoids are more numerous in the coal measures than the sharks. Their remains are found in better preservation, their bodies being covered with a dense bony envelope of shining scales of ganoine, and the internal framework being in most instances more or less ossified, the fossils are generally discovered in a tolerably perfect condition. In recent forms the ganoids exhibit in

some particulars close relationship with the Elasmobranchs; the *bulbus arteriosus*, with its many valves, more numerous in the ganoids, the chiasmic, non-decussating optic nerves and the spiral valve in the intestines, are all present, whilst in no other fishes are these characters to be found. There are other characters in which the ganiods differ from the sharks. In the latter the branchial arches are attached to the outer wall of the gill-cavity, the water passes by a number of slits in the dermal covering, usually five in number, and there is no operculum. The ganoids have free gills and an operculum, and in this respect they have near affinities with the Teleostei, whose gills are not attached to the walls of the gill-cavity, and they are protected by an operculum which forms the outer wall. There are other important characters in which the Ganoids resemble the Teleostei, notably in the possession by some of them of an air-bladder, which is preserved in the fossil state in the Cælacanths; and also in the fact, that many of the Teleosteans are possessed of a dermal covering of ganoine, developed from a membranous skin. I do not intend to enter fully into the several reasons for supposing that some of the carboniferous fishes exhibit characters or affinities which render their near relationship with the Siluroid Teleosteans probable, but further discoveries of fossil forms more especially in beds which are of decidedly fresh-water origin, will most likely reveal closer alliances between the fossils and the recent Teleosteans, than has hitherto been considered probable.

The knowledge of the mode of life and of the habits of the fish, to be gleaned from a careful consideration of their distribution and deposition, and the zoological affinities of their living allies, is perhaps not very extensive or decided, but there are a few facts which may be usefully remembered. The fish remains, in nearly every instance, are found on the surface of a bed of coal; instances rarely occur in which the remains of fish or other vertebrates have been discovered in the shales above the coals; in the sandstones, no instance has been recorded. There is thus, then, in every instance where they have been found a peculiar aggregation of fishes, whose modern representatives are of both marine and fresh-

water types. Being associated in death, they must have lived together, and the question naturally follows as to whether the marine forms adapted themselves to the environment of the fresh-water species or *vice versa*. There is the further consideration, that though the recent fishes live for the most part in their respective media and are incapable of adapting themselves to a different one; this may not always have been the case, and it is equally possible that during the deposition of the coal measures the sharks may have been fresh-water fishes, or the ganoids may have been marine. Amongst living fishes, the sharks are a large and numerous group, for the most part existing in the sea, but occasionally becoming more or less adapted to living in fresh-water. It is well-known that sharks of large size ascend many rivers such as the Ganges. The saw-fish has been observed in many rivers of both Africa, Asia, and the South Sea Islands; and sharks have been seen as far inland as Bagdad, in the river Euphrates, by Capt. Sleigh and others. There is also the instance narrated by the late Thos. Belt, of sharks inhabiting the Lake Nicaragua in Central America, completely cut off from all communication with the sea. These cases prove that even at the present time the Elasmobranchs have the power to adapt themselves to living either in salt or fresh-water. If we turn to the Ganoids we find that with the exception of the Sturgeons, they are all fresh-water fish, and do not possess any power or exhibit any inclination to migrate to the sea. The sturgeons live indiscriminately in either salt, brachish, or fresh-water, but of all the ganoid fish they are most unlike the fossil forms. Amongst the Siluroids and other Teleostean forms it is not uncommon to find marine forms ascending rivers to spawn or in search of food, but in no instance are the fresh-water species known to leave their native habitat and descend to the sea.

During Carboniferous times the most common and universal fish appears to have been Megalichthys, a ganoid of large size, attaining four or five, or even eight to ten feet in rare instances, in length, protected by thick rhomboidal scales and plates of

ganoine, with powerful jaws armed with large pointed teeth, evidently a predaceous fish, feeding probably on its smaller associates. Along with the Megalichthys there is frequently found a still larger ganoid, Rhizodus, which is known to be sixteen or eighteen feet in length, though the Yorkshire specimens are much smaller. In these coal measures it has only been found in one locality, above the Black-bed coal near Bradford; but in Scotland, at Gilmerton, it is of frequent occurrence, and teeth are in my collection which measure quite four inches in length, and scales of nearly the same diameter. The teeth and scales of Strepsodus (or Holoptychius) are generally found along with other fish remains in Yorkshire. The teeth of this fish have a peculiar twist towards the point which readily distinguishes them from any other species; they frequently occur nearly or quite two inches in length. The scales appear to have been softer and more loosely attached to each other than is usually the case with ganoids, resulting in their separation before becoming fossilized; consequently, specimens are rarely found of more than single scales, though one slab of shale about sixteen inches by ten, covered with scales and a large operculum, seemingly in proper position, indicates that the fish must have been several feet in length. The remains of Cœlacanthus are very abundant in the Yorkshire measures, decidedly the most frequent and characteristic fish of the period. In the lower coal measures it is not so well preserved or so common as in those higher up the series. In the shale above the Better-bed coal it is never found entire, but the bones of the head indicate a fish of about two feet in length. It is present in great abundance in the Cannel coal between Wakefield and Bradford, and is well and beautifully preserved. The specimens are of varied size, ranging from two and three inches to between eighteen and twenty-four inches. Associated with these ganoids were those of the genera Acrolepis, Platysomus, Rhizodopsis, and others which are occasionally found in exquisite preservation, but more frequently in fragments. One other ganoid should be noticed, though of comparatively rare occurrence in this coal-field it is more frequently

met with in others. Ctenodus is a genus closely allied to Dipterus of the old red sandstone, and serves as the connecting link during the carboniferous period, between that genus and Ceratodus, which still continues to exist. These, along with the recent Lepidosiren and Protopterus form a peculiar group of fish with acutely lobate paired fins. Their internal organization allies them closely with the ganoids, but they differ from the ganoids in possessing a modified air-bladder which enables them to breathe air, and so to exist out of water for long periods. These characters have been considered of sufficient importance by some naturalists to necessitate the creation of the order Dipnoi for their accommodation, whilst others taking their otherwise close resemblance to the ganoids into account, place them as a branch of that order. It is very probable that the latter may turn out their true position. The possession of an air-bladder, osseous or otherwise, is not restricted to these five genera, but is also to be found in many of the Siluroid Teleosteans, as well as the Lepidosteous and other ganiods, and in the Sirenoid fishes of the rivers of South America.

Amongst the fishes comprised in the Elasmobranchii the genera Ctenacanthus and Gyracanthus present features indicating that they attained to a very large size. The only known fossil parts of these fishes are the spines, analogous to those of the spiny dog-fish of our coasts, in which the spines are placed before each of the dorsal fins. Teeth and dermal tubercles have been at various times associated with the spines, but without conclusive proof that they belonged to the same genus of fishes. The spines of both genera are tolerably common and occur in greater or less abundance in every stratum where fish remains have been found. They are sometimes as much as two and a half to three inches in diameter and a couple of feet long. Along their posterior surface there is a deep groove to which the fin was attached. Some of the spines are worn at their distal ends and appear to have been attached to the pectoral fins, being worn by rubbing against the bottom, they indicate a fish which was a ground feeder and accustomed to a position on or near the bottom.

Pleuracanthus (including Orthacanthus Ag, Diplodus Ag, and Xenacanthus, Beyr) forms a large group and is distributed over the whole series of the coal measures. Several new species have been found in addition to the lœvissimus, cylindricus, and gibbosus of Agassiz. The whole series of about a dozen species is extremely interesting for many reasons which cannot be entered into at present. Acanthodes and Lepracanthus occur in the lower coal measures in the Bone-bed above the better-bed coal, and are not very rare. Hoplonchus and Phricacanthus, new genera, are also from the same bed. Several teeth which are supposed to have belonged to Elasmobranch fishes, as Cladodus, Ctenoptychius, Petalodus, Pœcilodus, and Helodus occur in some of the strata. Compsacanthus, a genus of fish, instituted by Dr. Newberry in the United States, with only one row of denticles along the dorsal surface, and hitherto unknown in this country, is now represented by two species from the cannel coal. To the genus Pleurodus, named but not described by Professor Agassiz, the Yorkshire coal measures have rendered specimens affording information on which to base not only a description of the teeth, but also of the spines. The fish was probably nine or ten inches long, very deep in the body, with a large gape and pavement-like teeth. At the highest point of the dorsal part of the fish a smooth spine was implanted, broad at the base but rapidly tapering to a point, and from two to three inches in length. The whole of the fish was cartilaginous.

One or two comparisons of the fish-fauna of the Yorkshire coal-field with those of other parts of the country may perhaps be useful. The principal supplies of fossil fish have hitherto been derived from the Scotch coal measures at Burdie House and Gilmerton; from Newsham, near Newcastle-on-Tyne (Low Main Coal-seam); from the Ironstone Shales of North Staffordshire, and from the coal measures of the West Riding of Yorkshire. Several of the Lancashire beds have yielded fish remains, notably the Arley mine, but not in such numbers or of sufficient diversity to render them of peculiar interest. Considered in relation to the other sources mentioned, the Yorkshire fossils are peculiar for the

great number of genera and species as, well as individuals, of fossil spines. The genera Gyracanthus and Ctenacanthus are common to all the localities, occuring in greater or less abundance, but the genera Lepracanthus, many of the species of Pleuracnthus, the genera Phricacanthus, Hoplonchus, and Compsacanthus have hitherto been peculiar to the Yorkshire coal-field. The great abundance of Cœlaeanthus may be also considered a peculiarity of this district, for, though the fish is found in Staffordshire and elsewhere, it is comparatively rare.

The Staffordshire district has been particularly rich in species of small ganoids. Palœoniscus (Elonichthys), which occurs in Yorkshire very sparingly, if at all, is extremely abundant and well preserved. The genera Platysomus, Cycloptychius, Acanthodes, and Amphicentrum are all well represented, as well as several others.

The Newcastle district is remarkable for the number and preservation of several species of Ctenodus, whilst Palœoniscus is rare, and the spines so common in Yorkshire are very rare. A larger proportion of Labyrithodonts are found intermingled with fish remains in this coal-field than in any other. Whilst on the other side the Tweed the principal feature of the fish-fauna rests in the presence of immense ganoids of the genus Rhizodus; these fishes, armour plated and possessing strong jaws armed with immense teeth measuring three or four inches in length, must have been most formidable adversaries to all other existing species. In no other district is the Rhizodus developed to so large a size as in the South Scotch coal-field. Thus we find that, whilst certain of the fishes are common to all the districts, like Megalicthys, Gryracanthus, and Ctenacanthus, there are others which were altogether localized, or which thrived much better in some localities than others. It will be an interesting work, when sufficient material shall have been accumulated from all these districts, to consider on what special features these diversities of fauna depend, and to endeavour to elucidate by these means the physical history of the carboniferous period.

	Halifax Hard Bed.	Better Bed Coal, Clifton.	Black Bed Coal, Low Moor.	Silkstone or Blocking.	Middleton Main Coal.	Yard or Joan Coal.	Adwalton Stone or Cannel Coal.	Barnsley Thick Coal.
CTENODUS,								
ellipticus, H. & A.	—	×	—	—	—	—	—	—
tuberculatus, H. & A.	—	×	—	—	—	—	—	—
elegans, H. & A.	—	—	—	—	—	—	×	—
CŒLACANTHUS,								
lepturus, Agass	×	×	×	—	×	—	×	—
elegans (?), Newb.	—	—	—	—	—	—	× ?	—
MEGALICHTHYS,								
Hibbertii, Agass.	×	×	×	×	×	×	×	×
coccolepis	—	—	—	—	×	—	—	—
STREPSODUS (Holoptychius)								
sauroides, Huxley	—	×	×	—	×	×	×	—
ACROLEPIS sp. ?	—	×	—	—	—	—	×	—
PLATYSOMUS sp. ?	—	×	—	—	—	—	×	—
RHIZODOPSIS sp. ?	—	×	—	—	—	—	×	—
ACANTHODOPSIS:								
Egertoni, H. & A.	—	×	—	—	—	—	—	—
AMPHICENTRUM sp. ?	—	×	—	—	—	—	—	—
PALÆONISCUS sp. ?	—	× ?	—	—	—	—	?	—
CYCLOPTYCHIUS sp. ?	—	×	×	—	—	—	×	—
GYROLEPIS,								
Rankinii Ag.	—	×	—	—	—	—	—	—
RHIZODUS,								
Hibbertii Ag.	—	—	×	—	—	—	× ?	—

	Halifax Hard Bed.	Better Bed Coal. Clifton.	Black Bed Coal, Low Moor.	Silkstone or Blocking.	Middleton Main Coal.	Yard or Joan Coal.	Adwalton Stone or Cannel Coal.	Barnsley Thick Coal.
GYRACANTHUS AG.								
formosus Ag.	—	×	×	—	×	—	×	—
tuberculatus Ag.	—	×	—	—	—	—	—	—
sp. ?	—	—	—	—	—	—	×	—
CTENACANTHUS AG.								
hybodoides, Egerton.	—	×	×	—	+	×	+	—
æquistriatus, Davis.	—	×	—	—	—	—	—	—
minor, Davis.	—	—	×	—	—	—	—	—
LEPRACANTHUS,								
Colei, Egerton.	—	×	—	—	—	—	—	—
HOPLONCHUS, Davis.								
elegans, Davis.	—	×	—	—	—	—	—	—
ACANTHODES,								
Wardi, Egerton.	×	×	×	—	×	—	×	—
PHRICACANTHUS, Davis.								
biserialis, Davis.	—	×	—	—	—	—	—	—
PLEURACANTHUS, AG, Davis. (ORTHACANTHUS), (XENACANTHUS),								
lævissimus Ag.	—	×	×	—	×	×	×	—
cylindricus Ag.	—	×	—	—	×	—	—	—
erectus, Davis.	—	—	—	—	—	—	×	—
tenuis, Davis.	—	×	—	—	—	—	—	—
pulchellus, Davis.	—	—	—	—	—	—	×	—
alternidentatus, Davis.	—	—	—	—	—	—	×	—
planus, Agass.	—	—	—	—	?	—	?	—
alatus, Davis.	—	—	—	—	—	—	×	—
robustus, Davis.	—	—	—	—	—	—	×	—
Wardi, Davis.	—	× ?	—	—	—	—	—	—
denticulatus, Davis.	—	×	—	—	—	—	—	—
(DIPLODUS),								
gibbosus Ag. (and others)	—	×	×	—	×	—	×	—
COMPSACANTHUS Newbury								
triangularis, Davis.	—	—	—	—	—	—	×	—
major, Davis.	—	—	—	—	—	—	×	—

	Halifax Hard Bed.	Better Bed Coal, Clifton.	Black Bed Coal, Low Moor.	Silkstone or Blocking.	Middleton Main Coal.	Yard or Joan Coal.	Adwalton Stone or Cannel Coal.	Barnsley Thick Coal.
OSTRACOCANTHUS, Davis.								
dilatatus, Davis.	—	—	—	—	—	—	×	—
PLEURODUS,								
affinis (Ag.), Davis.	—	×	×	—	×	×	—	—
Rankinii Ag.	—	×	—	—	—	—	—	—
HELODUS,								
Simplex, Agass.	—	×	—	—	×	×	—	—
sp. ?	—	×	—	—	×	—	—	—
PŒCILODUS sp. ?	—	×	—	—	—	—	—	—
HARPACODUS sp. ?	—	×	—	—	—	—	—	—
PETALODUS,								
Hastingsiæ, Owen.	—	×	×	—	×	—	—	—
CTENOPTYCHIUS,								
apicalis Ag.	—	×	—	—	—	—	×	—
CLADODUS,								
myrabilis, Agass.	—	×	—	—	×	—	—	—

ON A FAULT IN THE CHALK OF FLAMBRO' HEAD, WITH SOME NOTES ON THE DRIFT OF THE LOCALITY. BY G. W. LAMPLUGH.

I wish briefly to place on record the existence of a fault of some importance in the Chalk at Flambro' Head, which I do not think has been previously noticed, and for which allowance should be made in estimating the thickness of the Yorkshire chalk, or in attempting to trace its life-zones.

The well known Flambro' lighthouses stand near the extreme seaward point of Flambro' Head; and just below them is a little bay, if one may dignify by that name a somewhat wider break than usual in the line of wave-shaken cliffs, which, for some distance on either side of it, form a continuous series of picturesque arches, crannies, caves, and rock pillars.

This break is known by the country folk as Selwicks (pronounced *Sel-icks*) Bay. On the Ordnance and most other maps, this is written *Silex*. This is clearly a misnomer. *Wicks* and *Wykes* abound on our coast—not a mile and a half to the northward of this place is another and very similar recess, which is known as *Thornwick;* in which again the *w* is not sounded, except by strangers.

It is in the centre of this 'bay,' that the fault occurs; indeed it is owing to the fault that there is a bay at all, for the strata near it are much bent and broken, thus causing a line of comparative weakness, along which long centuries of toiling waves have had their usual effect; for, as has been pointed out by Professor Phillips,* wherever along the range of cliffs the chalk lacks aught of its accustomed hardness; wherever its strata are crumpled or shaken; wherever its flints become less abundant, or the rock softer; there, surely, do the tell-tale waves carve out a bold record of it in the beach-line.

I first came across the fault whilst examining the way in which flints make their appearance. Coming north from Brid-

*Geol. of Yorkshire, 3rd Ed., page 92.

lington, flints are seen for the first time on the southern side of the Head, just where the cliffs begin to be so cave-worn and fissured, in a recess known as *High Stacks.* They are here present on the scar nearly to the base of the cliff; but the chalk has a pretty constant rise northward, and they soon rise in the cliff foot, and by the time we have gained the point where the sea always washes the base of the cliff, and thus bars further advance, which is only a few hundred yards further north, the chalk contains flints nearly to the top of the cliff, which is here about 90 ft. in height (excluding the drifts).

Further advance in this direction being thus impossible, it is necessary to ascend, and to go on to Selwicks Bay before one can again descend in safety. Upon examining the south side of this bay, the cliff is again seen to have flints from top to bottom, occuring in irregular patches which form inconstant layers. Thence, they may be traced to the centre of the bay, where the beds become suddenly contorted and shattered, and dip down steeply at a constantly increasing angle until they are almost vertical. Here all the interstices of the shaken chalk are filled with veins of calc-spar.

In the cliff, the actual fault is concealed by a great mass of slipped drift, which has come down to the beach from above, over which a little stream winds its way, and this has no doubt caused the fault to be overlooked. On the beach, however, the actual line of fault, though somewhat obscured by the plenteous growth of tangled sea-weed, can be distinctly traced at low water.

On examining the evenly-bedded chalk on the north side of the slip, the existence of the fault is immediately proved; for there are no flints whatever in the cliff. Neither do they reappear until we reach the grand group of arches and passages, which, projecting seaward, form the northern side of Selwicks, where a few flints may be seen on their rocky pavement, under circumstances resembling those under which they first appear at High Stacks, viz.:—For a short distance they occur sparingly, but soon

increase in abundance on the beach, and again take their place in the cliff in force.

Reckoning from the data thus supplied, I should estimate the amount of downthrow to the north at about 80 feet.

As seen on the beach the direction of the fault is N.E. and S.W. Here also the tilted flint-bearing beds on the southern side are seen to abut against well-nigh level flintless strata on the north. For some distance on each side of the fault, however, there is no very regular dip.

I think it more than probable, chiefly on palœontological evidence, that a fault also exists in the chalk at Danes' Dyke, a deep valley between Flambro' Head and Bridlington. In this case the downthrow appears to be to the south ; but as yet I have attempted no estimate of its extent.

Before concluding, I would draw attention to some noteworthy facts in connexion with the drift which, as usual, caps the chalk above Selwick Bay.

This drift, which consists of several beds, or bands, of Boulder Clay (or Till) with gravel partings, has at its base, a curious and interesting layer of Blue Clay, which, upon examination, proves to have been chiefly derived fron the Neocomian and Kimmeridge clays, for which the nearest known locality is in the vale of Pickering, over seven miles distant.

This blue clay clearly shews its origin by plentiful fragments of such characteristic fossils as *Belemnites jaculum* of the Middle and Lower Neocomian ; *B. lateralis*, and *Exogyra sinuata*, of the Lower Neocomian, etc., along with nodules of weathered pyrites, from the Upper Neocomian, and with a few small red chalk pebbles.

Traces of this bed are first seen below the Fog-gun house, and may be followed thence northward to the north side of Selwicks, a distance of several hundred yards ; it may extend much further, though not seen in cliff section. In places it consists of pure Neocomian Clay, simply removed and in the condition of a boulder ; but more often it has had a few red and white chalk

pebbles worked into it, and sometimes passes into a kind of Boulder Clay.

It is most accessible, and best developed, just where a cave which opens into Selwicks Bay, shows, through the fall of its roof, a wide, gaping chasm to the land, not far from the Fog-gun house. It has a thickness here of not less than 10 feet.

The chalk below it possesses evidence of ice pressure in the form of a few slight crumplings which die away gradually downwards.

Similar patches of travelled beds have been noticed in the Boulder Clay near Filey; which are probably, however, not so far from home, being derived from the Middle Kimmeridge series. These patches seem to have been looked upon by Mr. Judd in his well-known paper on the Speeton Clays* as being in place; but this is not the case with any I have yet seen. Even in an exposure which I noticed *on the shore*, near Filey, the Kimmeridge Clay was surrounded by Boulder Clay.

Speeton fossils are not very rare in the 'Basement' Clay either at Bridlington or Dimlington.

These, and kindred facts, should be of value in tracing the probable direction of the ice-flow.

I may mention, too, that the 'Basement' Clay of Mr. S. V. Wood, appears to have an out-lier in the cliff at Selwicks just above the slip that covers the fault; but as the whole section here is much obscured, it is difficult to make out its relations. Enough that it possesses the characteristic peculiarities of that clay, and contains, as usual, an abundance of broken shells of northern species.

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*Quart. Geol. Journal, vol. xxix page 219.

GLACIAL DEPOSITS NORTH OF BRIDLINGTON. BY J. R. DAKYNS, M.A., H.M. GEOLOGICAL SURVEY.

IN my paper published in the "Society's Proceedings" for 1879, I mentioned that the Gravels immediately overlying the Purple Boulder Clay, North of Bridlington, have in some places masses of Boulder Clay included in their lower parts. The diagram, Fig. 1, shews this: it represents the top of the cliff from the wall and stile at the south edge of Sewerby Park, as far north as the point where the footpath leaves the cliff. The letters P.B.C. stand for Purple Boulder Clay, and R.B.C. for Red Boulder Clay.

I take from my note book the following: "Opposite Sewerby the gravel is interbedded with, and jammed against boulder clay in several places. East of the first turnip field, as you go eastwards, the gravel dies out, and the boulder clay is covered by a silty clay; but the gravel soon reappears under the silty clay, and continues (though thin) resting on boulder clay, against which it seems to be jammed near the east end of the grass field. Beyond this all is obscure. Boulder clay seems to be at the surface; then we have a hollow, like the site of a pool or stream course, occupied by gravel, probably recent. Beyond this we have well-bedded gravel at the top of the cliff over boulder clay." This last mentioned gravel is the thick bed of gravel of drift pebbles, which forms the top of the cliff at the Danes' Dike valley.

Another note says that "In the first turnip field east of Sewerby Hall, opposite the first round plantation the Sewerby gravel is overlaid by clean red clay, which is seen at intervals nearly as far as the east end of the field. This clay is in some places seen to be laminated. The section of the whole cliff hereabouts is as follows:

Clean red clay, alluvial,
on Gravel, the Sewerby Gravel,
on Boulder Clay, part of the Purple Boulder Clay,
on Sand, probably the same bed as that which divides the P.B.C. at Bridlington,
on Boulder Clay, the lower part of the Purple Boulder Clay,
on Chalky Gravel, not continuous, but very general,
on Chalk."

At the second fence east of the Park we have as heretofore, gravel on boulder clay: but immediately east of this, the boulder clay reaches to the top of the cliff; the ground now becomes slipt, and there may be recent alluvial beds over the boulder clay.

At the next fence, viz., that south of Danes' Dike Farm, there is clean red alluvial clay, and a doubtful patch of red boulder clay lying on gravel, probably the Sewerby gravel, which in its turn overlies the normal purple boulder clay. Then comes a hollow, occupied by sand and gravel, probably recent alluvial, over the boulder clay. East of the hollow, near the next fence to the Dike Valley, we have

Sand and Gravel, not chalky,
on Boulder Clay,
on Sand and Gravel,
on Chalky Gravel,
on Chalk.

On another occasion I saw the following section opposite the Danes' Dike Farm, viz:—

Sand and Gravel
on Boulder Clay,
on Sand and Clay, Warp,
on Sand,
on Boulder Clay,
on Chalky Gravel,
on Chalk.

Between the last mentioned fence and the Dike Valley, the beds exhibit the changes shown in the diagram, Fig. 2. I give this figure, though it is neither a picture nor drawn to scale, but merely a diagram, because hitherto it seems that geologists have not had such a clear section of the cliff at the Danes' Dike, probably owing to their visiting it in summer; now in summer the face of the cliff is apt to be masked by wash, as well as hidden by vegetation; the only time to get clear sections, is when the face of the cliff is kept continually fresh by heavy rain and ever new landslips: and winter is the time for this.

The section of the beds on the west side of the Danes' Dike Valley, when fully developed, consists of the following members:

A Bedded Gravel of Drift Pebbles,
on B Boulder Clay, six feet thick,
on C Chalky Gravel seven feet thick,
on D Boulder Clay,
on E Sand,
on F Boulder Clay,
on G Sand and Gravel,
on H Chalky Gravel, well-bedded, thinning out rapidly eastwards,
on I Boulder Clay,
on J Angular Chalk *débris* and gravel, which dies out east of the valley,
on K Boulder Clay,
on L Sand, about six feet thick,
on M Fine Chalkwash, in twisted laminæ about six feet thick,
on Chalk.

The bed M, is like the chalky rain-wash, due to subærial denudation or weathering, which is apt to clothe the bottoms and sides of valleys in the chalk.

The Fig. 3 represents the curious contortions of its laminæ, due probably to slipping.

The sand bed E, ends abruptly under boulder clay on the west: it is not a well-bedded sand, but its layers seem to be twisted back under the boulder clay from west to east; it would thus seem as if the boulder clay D, had been deposited in a hollow, scooped out of the sand E, by some agent acting from west to east; this could hardly have been anything else than floating ice.

Owing to the thinning out of the other beds, the section on the east side of the valley consists of the following members alone, viz:—

Gravel, A,
on Boulder Clay, B,
on Chalky Gravel, C,
on Boulder Clay, F, I, K,
on Sand,
on Chalk wash,
on Chalk.

In the valley itself, some little way up, the section is:—

Sand and gravel,
Boulder Clay,
Chalky Gravel, nine feet,
Space hidden by tumble,

Boulder Clay, unconformable,
on Angular Chalky Gravel, unconformable,
on Fine Chalky Gravel. As shown in Fig. 5.

The bed C, continues nearly as far as the second fence, where it dies out. The bed A, has a patch of red boulder clay over it near the end of the Dike; a bed of gravel continuous with A, stretches from the Dike to Beacon Hill; at Hartingdale Gutter, between the Dike and Beacon Hill, this gravel is well seen; it is here very chalky: this fact implying a total change of character, causes one to suspect that the Hartingdale gravel may be a newer gravel, deposited in a hollow scooped out of A, which it replaces; but though I carefully searched the cliff I could find no section shewing that this was the case.

As one ascends the slope of Beacon Hill an earthy boulder clay comes on over the gravel A; this boulder clay is succeeded eastward by a great thickness of well-bedded sand and gravel, containing fragments of marine shells, which formes the whole thickness of Beacon Hill above the purple boulder clay, but there was no section sufficiently clear to show the relation of the upper earthy boulder clay to the sands: on the other or eastern slope of the hill however a similar boulder clay is seen to lie across the denuded edges of the sand beds, as shown in Fig. 6.

Thence to Flamborough South Landing, the top of the cliff is formed of Boulder clay. Near the fence next to the landing, sand and gravel come in between the boulder clay and the chalk. At the South Landing such beds fill up a preglacial chalk valley; they consist of chalk gravel, and conglomerate; some of it very course, highly cross-bedded; and in one part, unfortunately quite inaccessable, apparently consisting of angular blocks. The coarse chalky gravel contains a few foreigners: the dip of the cross-bedding is towards the west.

The bedded gravel consists of water-worn stones and has evidently been tipped over the east side of the old valley. The angular portion is unbedded and moraine like in its character; but its relation to the other beds is not clear. The bedded gravel is over-

laid by sand and laminated sandy clay, and these by brown boulder clay light coloured, and this by dark brown boulder clay reddish at top, there being in places a thin parting of sand or gravel between the two boulder clays.

Some way north of South Landing we have

Reddish Boulder Clay
on Chalky Gravel,
on Mixed Gravel,
on Purple Boulder Clay.

The various divisions cannot be traced continuously.

At High Stacks, as shewn in my paper read at Driffield, we have

Red Boulder Clay,
on eroded surface of Chalky Gravel,
on eroded surface of Boulder Clay, unconformable,
on Chalky Gravel,
on Boulder Clay,
on denuded edges of Gravel,
on eroded surface of Purple Boulder Clay.

Again, south of Thornwick we have

Boulder Clay, weathering red,
on Gravel, unstratified,
on Purple Boulder Clay,
on Chalk rubble, thick,
on Chalk.

And north of Thornwick we have

Purple Boulder Clay,
on Boulder Gravel, passing into stratified gravel 9 feet, passing into Boulder Clay,
on Purple Boulder Clay, 25 feet,
on Gravel and Sand, } 15 feet,
on Conglomerate, }
on Chalk.

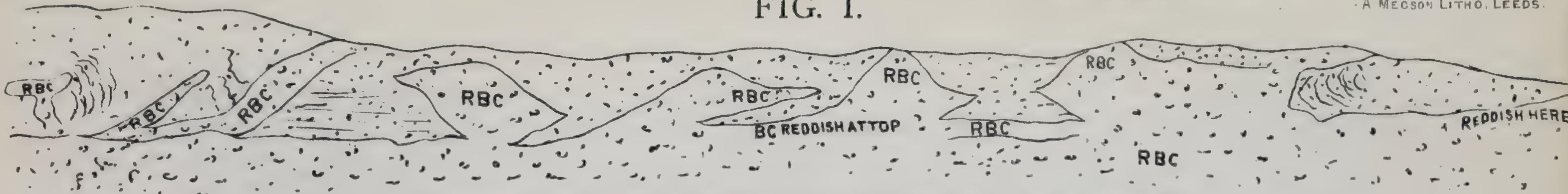
And* at Thornwick Cottage there is red boulder clay on gravel with shell fragments, both of which are probably above the beds seen in the cliff.

Boulder clay stretches continuously over the sea-ward end of

* The beds at Thornwick Cottage are certainly above those seen in the cliff below; and are no doubt the same as the similar beds at Beacon Hill. The boulder clay is probably the same as that which covers the lower slopes of the Wold continuously from Hessle to Bridlington. The sand and gravel may be the same as the shell bearing sands of Kelk and Brandesburton.

A Megson Litho, Leeds.

FIG. I.



PURPLE BOULDER CLAY.

Section of upper part of cliff from south edge of Sewerby Park, to the valley at which the footpath leaves the cliff, shewing the Sewerby Gravel dove-tailing with Boulder Clay.

FIG. II.

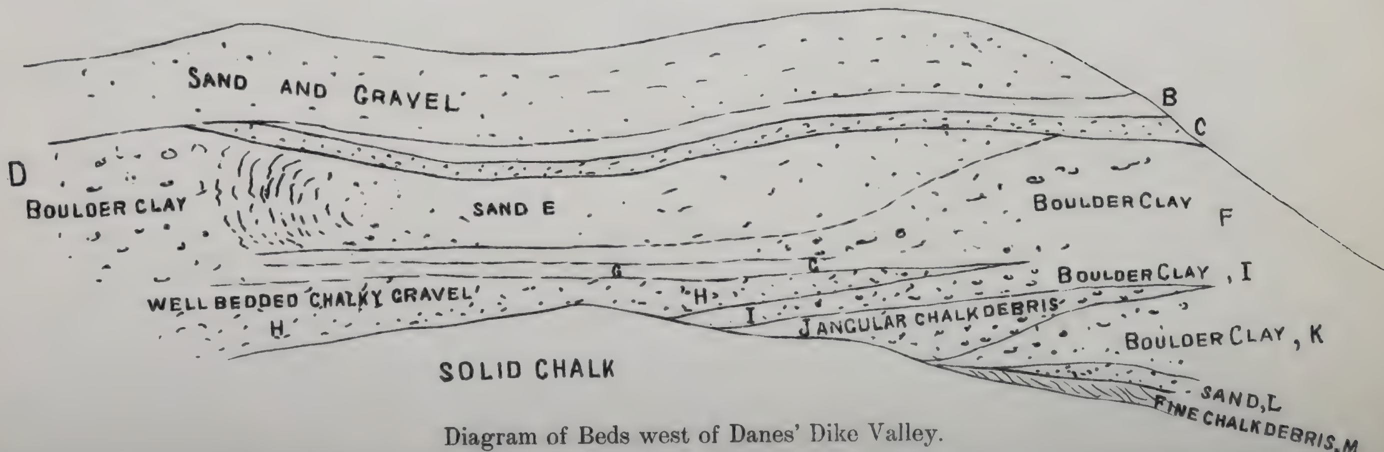


Diagram of Beds west of Danes' Dike Valley.

FIG. III.

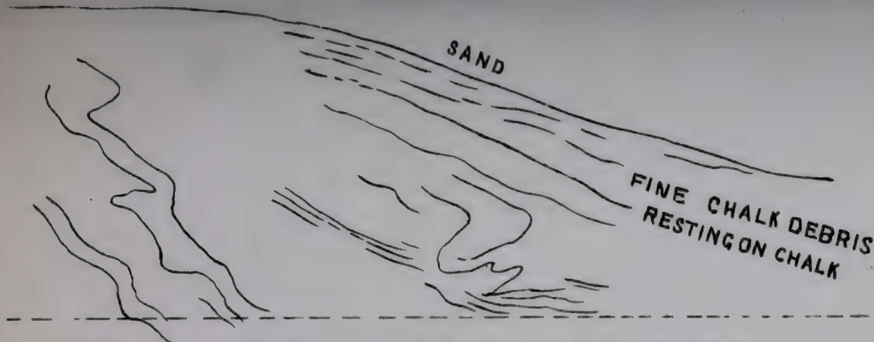
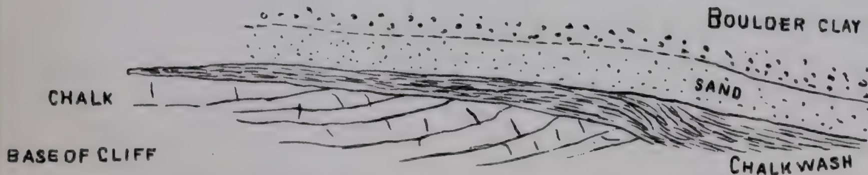


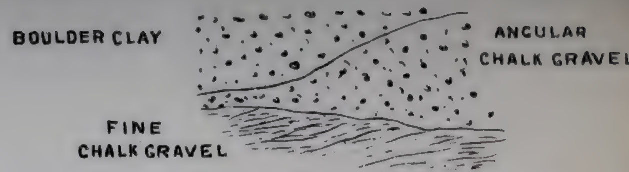
Diagram to shew the character of the Laminæ in the Chalk Wash beneath Glacial Deposits at Danes' Dike. The Chalk Wash is about six feet thick, and rests on chalk.

FIG. IV.



Shewing the true slope of the surface of chalk on which the Chalk Wash rests.

FIG. V.



Section in the Danes' Dike Valley, shewing the junction of the lowest Boulder Clay there seen, with the underlying deposits.

FIG. VI.

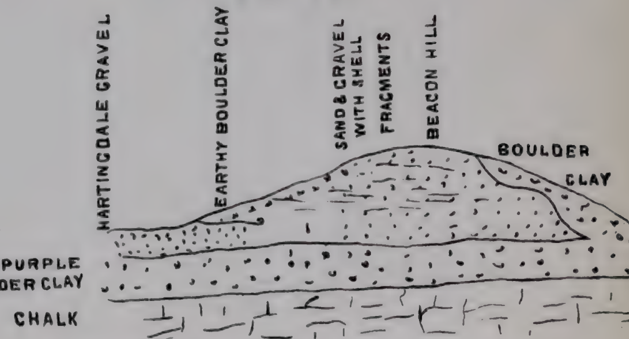


Diagram shewing an upper Boulder Clay lying on denuded edges of Sand Beds containing fragments of Marine Shells. Slope of hill greatly exaggerated.

the Wolds, from Bridlington to the chalk escarpment: over the very highest cliffs the topmost red weathering boulder clay seems often to be alone present. It often becomes so stony that it is hard to say whether it should be called gravel or boulder clay; and quite in keeping with this we find that mounds of gravel, when traced to the cliff edge, seem to end in this earthy boulder clay; thus the gravel mounds, stretching from Speeton along the top of the chalk escarpment, pass into boulder clay, as far as one can judge in the absence of perfectly clear sections.

Phillips long ago remarked that the boulder clay north of Flamborough, and even south of it too, was everywhere in two divisions; and Messrs. S. V. Wood and Rome have divided the boulder clay of Holderness into three. The sections given above, shew however that in many places there are more divisions than two or three: for instance, at High Stacks there are seven divisions at least, four of which are boulder clay; and at the south end of the Danes' Dike there are as many as thirteen divisons, five of which are boulder clay.

The section at Danes' Dike further shows that the chalky gravel, which has been described as so frequently lying at the base of the glacial beds immediately upon the chalk, is by no means everywhere one and the same bed, for at the west end of the section, the chalky gravel H, rests immediately upon the chalk; but eastward a lower boulder clay I, comes in below H, and still further east a lower chalky gravel J, comes in below I, resting on the chalk itself; while in the centre of the old preglacial valley, a third bed M, composed of chalk *dêbris*, comes in between all the other glacial beds and the chalk itself.

The character of the beds resting immediately upon the chalk, in several places, resembling as they do ordinary atmospheric detritus, supports the idea that the boulder clay was deposited upon a land surface; and the frequently disintegrated character of the chalk itself, noticed by Phillips, tells the same way. At the same

time the chalky gravel resting on the chalk is often well water-worn; but it probably is either old river gravel, or sea beach.

P.S.—I have recently seen boulder clay over the gravel A, on the west side of the Danes' Dike Valley.

ON THE AGE OF THE PENINE CHAIN. BY E. WILSON, F.G.S.

Printed in the Geological Magazine, November, 1879, and in the Midland Naturalist.

A SHORT HISTORY OF THE CRESWELL CAVES. BY THE REV. J. MAGENS MELLO, M.A., F.G.S., ETC.

PLEISTOCENE DISCOVERIES IN DERBYSHIRE.

The first discovery of the Pleistocene Mammalia in Derbyshire was, I believe, made as long ago as 1822, when the remains of the Woolly Rhinoceros, the Reindeer, and some other animals were found in the Dream Cave, near Wirksworth. This cave however was never the habitation of wild beasts, but had been a trap in which they had miserably perished; it was one of those swallow holes so common in the Limestone districts. Since then, until I had the good fortune to light upon the Caves at Creswell, but few traces of the extinct animals were met with in the county; the Mammoth, Rhinoceros and Hippopotamus were found close to its W. border at Waterhouses, and the first of these animals was also met with at Doveholes and near Castleton, in conjunction with the Rhinoceros. Abundant remains of the Reindeer and Bison, accompanied by the Bear and the Wolf, were discovered by Mr. Rooke Pennington, at Windy Knoll, close to Castleton; and still more recently a fissure at Matlock Bath has yielded specimens of some of the more common of the Cave mammalia.

THE CRESWELL CAVES.

The Creswell Caves are remarkable in that they do not occur as do the majority of Bone Caves in the carboniferous limestone, but in Dolomite of the Permian series. They consist of a few

small caves and fissures situated on either side of a short and picturesque ravine, cutting through the Lower Magnesian Limestone escarpment on the N.E. border of Derbyshire; one side of the ravine being in that county, the other in Nottinghamshire. The Caves which have been explored are four in number, viz.:—The Pin Hole, Robin Hood's Cave, and Mother Grundy's Parlour on the Derbyshire or north side, and the Church Hole on the south. The Cave first examined was the Pin Hole, a narrow and somewhat lofty fissure, running for some 50 yards into the crags in a northerly direction. The floor consisted in descending order of

1.	Surface soil, with recent pottery, bones, etc., ...	1ft. 6in.
2.	Red sand, with angular blocks of limestone, quartzite pebbles and bones	3ft.
3.	Light coloured sand, consolidated by infiltration of lime. No bones	?

A single flint flake was found just below the surface soil of this cave.

In bed No. 2 very numerous bones and teeth of the Pleistocene animals were discovered, most of them broken, and some evidently gnawed by Hyenas, of which animals many teeth occured. Owing to the dampness of this Cave many of the bones were considerably decomposed, whilst others were in a fine state of preservation; there would appear to have been some amount of rearrangement of the contents of the floor by occasional floodings, and a few vertebræ of fish and scales were here and there present.

The following list will show what remains were found in the Pin Hole, the determinations having been made by Prof. G. Busk, F.R S.

1. Homo.	10. Ovis.
2. Ursus sp?	11. Bos primigenius.
3. Gulo luscus.	12. Equus caballus.
4. Canis vulpes.	13. Rhinoceros tichorhinus.
5. „ lagopus.	14. Elephas primigenius.
6. „ lupus.	15. Lepus timidus.
7. Hyæna spelæa.	16. Arvicola.
8. Cervus megaceros.	17. A bird, sp?
9. „ tarandus.	18. Fish, sp?

Of these all except the sheep and the bird were probably of Pleistocene age. The Hyenas, whose remains have been preserved,

were mostly aged individuals, judging from the worn condition of their teeth. One of the Wolves of this cave was a large one, and is considered by Prof. Busk to "approach more nearly the American than the existing European species."

The discovery of the Arctic Fox, C. lagopus is noteworthy as being the first recorded find of this species in Great Britain, of it Prof. Busk says:—"I have little or no hesitation in referring "the axis from Creswell Crags to 'Canis lagopus,' thus adding "that species, so far as I am aware, for the first time to the British "antral fauna; the association moreover of this species with the "Reindeer, Glutton, and Elk, cannot be regarded as at all im-"probable." The Arctic Fox is known to have been common in Middle Europe, and was familiar to the cave men of Switzerland, who pictured it occasionally on the bones of the Reindeer. The bones of the Woolly Rhinoceros were mostly gnawed by Hyenas, these animals however do not seem to have been so prominent amongst the cave fauna of the Pin Hole as they were in some of the other Caves, as many of the bones of the Reindeer, Bos, and other animals show no traces of gnawing, and are quite perfect.

ROBIN HOOD CAVE.

We will now turn to the Robin Hood Cave, in which remains of the greatest interest and importance were discovered. This Cave is somewhat irregular in form, consisting of two large chambers, with smaller ones opening out from them. On the left hand side a deposit of limestone breccia and stalagmite covered a considerable portion of the floor, and was in several places united by stalactites to the roof; this breccia varied in thickness from a few inches up to at least 3 feet, thinning from the centre of the Cave towards the interior and right hand side; beneath the breccia a bed of cave-earth was found which was pretty uniformly distributed throughout the cavern, although varying both in thicknes, mineral composition and colour, where the breccia attained its greatest development the cave earth was thin, being only a few inches thick, but under the thinner parts of the breccia it was as much as three feet thick. In that part of the Cave where the breccia and stalagmite occured,

the cave earth was light in colour and very calcareous, but in other parts where it was thicker it was darker, and in two of the chambers (G. and F.) its lower portion contained numerous fragments of limestone, giving it a mottled appearance. Below the cave earth and breccia a local deposit of gravel and conglomerate occurred, the result, it may have been, of some sudden flood or of a stream running for a short period through part of the Cave.

The Cave-earth rested on a bed of red sand, similar in character to that already described in the Pin Hole. Some portions of this sand were highly ferruginous, and had a good deal of tough laminated red clay mingled with it in its lower portions, especially near the entrance of the Cave. This clay may have been connected with the same flow of water by which afterwards the gravel was brought in. The lowest deposit found was whitish sand with angular blocks of limestone, which evidently formed part of the original floor of the Cave. A general section of the beds of the Robin Hood Cave gives us in descending order

1. Surface soil, recent, and Romano British remains.
2. Stalagmite and breccia, flint implements and bones.
3. Cave earth, variable, bones and implements.
4. Red sand, clay at base, bones and implements.
5. Whitish sandy floor.

In the surface soil of this Cave some remains of the fugitive Romano British populations were found, consisting of fragments of Samian and other earthenware, bronze fibulæ, and a roughly carved bone with an iron socket, which may have been the boss of a sword or dagger. Numerous bones of animals common in prehistoric and Roman times were present in the same soil, amongst others the Celtic shorthorn, the goat and sheep, the stag, wild cat, badger, fox and horse.

The succeeding deposits of the Cave, with somewhat remarkable suddenness, carry us at once from the ages of history into that far distant past when the wild fauna of the Pleistocene epoch, the contemporaries and antagonists of the Palæolithic tribes of men were present in full force in this country; of the intervening Neolithic and Bronze ages there was no certain trace found in this

Cave; and when the breccia was accumulating, the Hyena and the Wolf, the Bear and the Fox, preyed on Reindeer, and Horses and Hares; whilst the Woolly Rhinoceros and Mammoth were also inhabitants of the locality.

The remains found in the breccia may be classed with those in the upper parts of the Cave earth, as this was a contemporary deposit, and it appears that whilst the Cave was now and again occupied by the Hyenas, who in vast hordes haunted the neighbourhood and dragged their prey into the recesses of the Creswell Rocks, man was also no infrequent visitor, for in the same deposits containing the teeth and bones of the Pleistocene animals many implements, scrapers, awls, flakes, and lance heads of flint occured, as well as some made either of bone or antler; besides such other traces as fragments of charcoal, a piece of amber, and bits of ruddle; this latter substance being probably used by the old Cave men for personal adornment. The bone implements consisted of some sharpened antler tips and an awl. From the character of these implements, and still more from that of the flint lance heads, found with them in the breccia and upper Cave earth, Prof. Dawkins has formed the conclusion that the men who made them were of the same race as those who used weapons and tools of the same type in the Caves of Perigord. The lance heads found at Solutré, and La Madeleine, and Laugerie Haute might all have been fashioned from models familiar to the Creswell hunters; a still further point of connection between the two is furnished by the discovery in the Robin Hood Cave of an engraving of a horse's head on a fragment of rib, the only trace hitherto found in this country of an art, which judging from the more numerous engravings of animals found in some of the Continental Caves, seems to have been practised with considerable success in those early days of human history in Europe; France, Belgium, and Switzerland, have all furnished examples of this primitive culture.

When we come to the lower parts of the Cave earth and to the underlying red sand in the Robin Hood Cave, we find that whilst the same fauna were present, a less cultivated tribe of men

disputed with them the possession of the Caves. The more elaborated flint implements, as well as those made of bone, have disappeared; rough chips only of flint, and still ruder weapons and tools made of broken quartzite pebbles, seem to have been the only ones in use; quartzite implements, and one or two of clay ironstone, alone beiug met with in the lowermost bed. These quartzite and ironstone implements, mostly trimmed in the roughest way by a few chips struck off here and there, bear a strong resemblance to the rude forms found in the River Gravels, and in the lowest beds of Kent's Hole and Wookey Hole, in this country; and to others found abroad in such Caves as Le Moustier, in the Dordogne, and in the Kesslerloch. The American Indians of Wyoming are said to make use of equally rough tools for the preparation of their hides. Some of these pebble implements have evidently been used as hammers, perhaps for the purpose of breaking up bones for the extraction of the marrow, such broken bones attesting man's presence, being very numerous in the Caves.

One of the most important results derived from the explorations of the Creswell Caves, is the remarkably clear evidence that has thus been afforded by the orderly distribution of these works of Palæolithic man, of regular stages in his history, and of a progress in civilization, and "a direct relation in point of time has been established between the rude types of implements below, and the more finished ones above;" the rude implements of quartzite were used before the more highly finished ones of flint. What these Palœolithic men were like we have no certain means of knowing, but by a careful comparison of their implements and habits of life, so far as these latter can be ascertained, it appears that there is much to connect them with the existing Esquimaux,—that hardy race of hunters and fishermen who would thus seem to have been driven in the long course of ages, in company with the Arctic animals, to more northern climes.

It is probable that these primitive Cave Men wandered about in small tribes or families, and the Caves would be occupied by them only at intervals, meanwhile the hordes of wild beasts which

infested the forests of the neighbourhood would reign supreme at Creswell; the most numerous being the Hyenas, which with Rhinoceroses, Horses and Reindeer, far outnumbered the other animals. Remains of Hyenas occur of all ages, from the cub just cutting its permanent teeth, to the decrepit veteran with mere stumps worn down nearly to the gums; that the Hyenas were to a great extent the masters of the Caves is proved by the gnawed state of a very large number of the bones of the other animals found, not merely of the Reindeer and the Horse, but even those of such powerful antagonists as the Woolly Rhinoceros and the Mammoth, which would occasionally be overcome by sheer force of numbers, or attacked at a disadvantage and driven over the crags, at the foot of which, maimed and disabled, they would fall an easy prey to their cowardly foes.

Amongst the larger Carnivora whose remains have been found at Creswell were the Lion, several of the teeth of which as well as other bones were met with, the Leopard, and two species or sub-species of Bears, the brown bear and the grizzly. A wild Cat of large size was also present, whilst the Glutton, Fox, and Wolf have been previously mentioned; but the most formidable of all was the great sabre-toothed Tiger, the Machairodus latidens. Kent's Hole is the only Cavern in this country where the remains have been previously found, but its teeth have been met with in the forest bed in Norfolk, and also in two localities in France. This animal appears to have survived from the Pliocene age, when together with another species, the "Cultridens," it was an inhabitant of N. Western Europe. At Creswell, in the Robin Hood Cave, a fine and well preserved crown of a large canine tooth was found; its mineral condition and colour totally forbid the hypothesis that it was derived either in ancient or modern times from any foreign locality; all the known remains of this animal, whether from the forest bed or continental Pliocenes, being of a different colour to this tooth, and in a very different state of preservation; whilst this specimen agrees in every respect of preservation and colour with the other Pleistocene teeth found in the Creswell

Caves; that it was brought there by some of the Palæolithic hunters is probable from its broken condition, but its appearance shows that its owner was a contemporary of the other animals of the locality, and was, it would appear, found dead, or else was killed by one of the early Cave dwellers, who would prize its sharp saw-like teeth as most useful implements. The Woolly Rhinoceros as well as the Mammoth not only visited the district, but bred in it, as is evidenced by the large number of milk teeth found in the Caves.

THE CHURCH HOLE.

The sketch I have now given of the Robin Hood Cave and its contents would in most respects apply to the Church Hole Cave, which has a tolerably wide entrance chamber opening into a long narrow fissure; the general sequence of its beds agrees closely with those of the former Cave, only differing in unimportant details; whilst the evidence of the Robin Hood Cave as to the stages of progress in civilization during the Palæolithic age is fully borne out by the remains found in the Church Hole. Human implements both of bone and flint were met with in the breccia, where present, and in the Cave earth, whilst the ruder forms of quartzite were characteristic of the lower beds; some of the bone implements from this Cave were carefully made, and consisted of a needle, some awls, grooved cylinders, which were probably spear heads; "the group of implements from the upper strata is, on the whole, of the same general type as that of the Robin Hood Cave, although no fragments of the elaborately chipped 'lance-heads' of the "type de Solutré" were discovered, nor any implements of the S. Acheul or Moustier forms."

The wild animals which have left their remains in the Church Hole call for no special remark, the history of the two Caves would be contemporary, and the animals frequenting the one would also find their way into the other; the only observed difference apart from the absence of one or two species in the Church Hole, and the presence there of the Pole Cat, is that Hyenas seem to have been particularly partial to this Cave during the earlier stage of

its history; for whilst in the lowest beds of the Robin Hood entire bones, vertebræ, metacarpals, etc., of the Bison and other animals were found intact, the larger portion of the Church Hole remains were in a very fragmentary state. In the surface soil of this Cave, as in the other, various Romano British relics, such as broken pottery, a bronze fibula, and a few other objects were met with.

MOTHER GRUNDY'S PARLOUR

We have now to turn to the last Cave of the series, Mother Grundy's Parlour, a widish and shallow chamber or rock shelter, with a long fissure branching off from its eastern side. There was here little or no Cave earth corresponding with the upper Cave deposits of the Robin Hood and Church Hole Caves, and the surface of the beds in the Parlour had been at one time or other considerably disturbed, but where a true section was obtained the following succession appeared:—

1. Surface soil, a few inches thick.
2. Red sandy earth, with bones, etc., 3 feet.
3. Red clay, with bones, etc., 6 inches to 3 feet.
4. Ferruginous, yellow and red sand, with bones, 1 foot.
5. White calcareous sand, no remains.

In the surface some burnt bones, charcoal, and a few flint chips and flakes were met with of no importance, but in the underlying red sand which was evidently the equivalent of the very similar bed in the other Caves, numerous remains of animals occurred, these consisted chiefly of the Reindeer, the Bison, the Bear, Wolf, Fox, and Hyena; a very large number of the coprolites of this last animal testified to its having inhabited the Cave for a considerable time. Very few implements were found, the only specimens being rudely chipped quartzite pebbles, similar to those previously described. The most interesting remains obtained from this Cave occured in the red clay and the underlying ferruginous sand, in these were discovered bones and teeth of two animals which we had not previously met with, namely, the Leptorhine Rhinoceros, of Owen, and the Hippopotamus, associated with skulls and jaws of the Hyena, and bones of the Bison; but the Horse, the Woolly

Rhinoceros, and the Mammoth, appear to have been absent at the period when these remains were being accumulated : no implements either of man were found in these lower deposits. The Hippopotamus remains represent three young adults, and consist of "fragments of a skull, and the complete molar series of both sides of the upper jaw, one premolar and two upper incisors all belonging to one individual, and portions of the jaws and other bones of two of its companions. The presence of the Hippopotamus and its associate the Leptorhine Rhinoceros, seems to characterise a period earlier in date than that of the remains found in the other Caves, and "these two animals are"—it has been pointed out by Prof. Boyd Dawkins—"so frequently companions in the Caves and river deposits in Britain, that there is reason for believing that they mark a stage in the Zoclogy of the Pleistocene period. Both are southern species, and are associated together in no less than sixteen caverns and river deposits in this country, and are very generally accompanied also by the Elephas Antiquus." Like the Machairodus the Hippopotamus is a survival from the Pleiocene age, and is, as well as that animal, met with, as has been said, in the Forest Bed of Norfolk. From the association of the Hippopotamus and the Leptorhine Rhinoceros with the Reindeer in the Yorkshire Caves, as well as elsewhere in England, Prof. Dawkins further says that he should feel inclined to consider them characteristic of that period in which the southern animals were living in this country, but were suffering from the competition of Arctic invaders driven southwards by the lowering of the temperature—that is to say—in the middle stage of the Pleistocene. It must be further remarked that these two animals were among those which the Palæolithic hunter saw when he arrived in this country, in his expeditions along the valleys now covered by the English Channel and the North Sea. They are found in one Cave only in Britain, the Cave of Pont Newydd, along with Palæolithic implements, which are fashioned out of quartzite, like those of the red sand in the Creswell Caves. They occur also in the Palæolithic river gravels of Brandon and Peckham, along with implements of the type

Acheulien of De Mortillet. Q, J. G. S., Nov. 1879.

The remains of historic or prehistoric age found in Mother Grundy's Parlour, consisted of the bones of such recent animals as were commonly met with in the surface soil of the other Caves, the sheep, goat, shorthorn ox, pig, etc. Besides these, some portions of human skeletons also occured, representing four young individuals, which appeared to have been buried in the Cave, and two skulls, found, one in the entrance chamber, the other in the side fissure, belonged to two different types, the former being brachycephalic or roundheaded, the latter dolichocephalic or long headed; neither of them however are considered by Prof. Dawkins to date from the Paleolithic age, they were found in disturbed soil, and as far as mere appearance goes, the one may have belonged to one of the early Celts, and the other to an individual of that long-headed Iberic race—the traces of which are still to be met with amongst the populations of Western Europe.

CONCLUSION.

The history of Creswell is now tolerably complete; it carries us far back into those dim Geological ages when our island was united to the Continent, and the Hippopotamus and its companion Elephants and Rhinoceroses, found their way from the south as far north as Yorkshire from their southern home, when the dark pine forests which then clothed much of the country re-echoed to the roar of the Lion and the Leopard, the howl of the Wolf, and the horrid laughter of the Hyenas; up the long eastern valley we may picture to ourselves the wandering tribe of hunters and fishermen making their way, halting now here now there, until they rest for awhile in the sheltered ravine at Creswell, where with their rude implements of stone they little by little fight their way up to higher stages of culture, or may be overcome in the hard struggle for existence and replaced by tribes slightly more advanced in civilization than themselves. How long a time elapsed, who shall say, at one time the Caves would shelter the hunter, at another they would be the dens of Hyenas and other savage beasts; whilst many vicissitudes of climate must have been experienced by

men and animals alike ; for whilst the rivers at one time were open enough to allow the Hippopotamus freely to make its way far to the north, and when the inhabitants of warm or temperate climates haunted the forests of Creswell, at another we find the Reindeer and the Glutton, together with the Arctic Fox, equally abundant ; and we also find in the closest connection such now widely separated animals as the Reindeer and the Hyena, which must in those early days have constantly met in the neighbourhood, the former being no unfrequent victim of the latter, as witnessed by the gnawed fragments of its skeleton now discovered in the Caves.

Of the Neolithic age we have no very clear traces at Creswell, unless the skulls which have been mentioned are without doubt to be attributed to that period ; but the men who used the polished stone implements, so frequent in the tumuli of this and other countries, have not left any plainly recognizable relics of their workmanship in these Caves ; and although doubtless the tramp of the Roman legionaries would have been now and again heard in the neighbourhood, a few coins and ornaments alone remain to tell of their higher civilization, and of that age when their effeminate subjects were on the withdrawal of the Imperial troops driven to the Caves by the warlike Saxons and other invaders. Mediæval pottery and a coin, together with the refuse of yet more recent days, carry on the history, and bring us to the Creswell of to-day, from around which has long since disappeared the primeval forest and wild fauna of earlier times.

I append a complete list of the animals which have been found in the Caves, separating those of the Pleistocene age from those of later date, and also showing their distribution in the respective Caves ; the determination in the case of all the Caves except the Pin Hole having been made by Prof. Boyd Dawkins.

LIST OF THE PLEISTOCENE MAMMALIA OF THE CRESWELL CAVES.

		Pin Hole.	Robin Hood.	Church Hole.	Mother Grundy.
1.	Machairodus latidens		×		
2.	Felis spelæa—Lion		×	×	
3.	Felis catus—Wild Cat		×		
4.	Felis pardus—Leopard		×		
5.	Mustela putorius—Pole Cat			×	
6.	Hyæna crocuta—Spotted Hyena ...	×	×	×	×
7.	Canis vulpes—Fox	×	×	×	×
8.	Canis lagopus—Arctic Fox	×			
9.	Canis lupus—Wolf	×	×	×	
10.	Gulo luscus—Glutton	×			
11.	Ursus Arctos—Brown Bear	×	×	×	×
12.	Ursus ferox—Grizzly Bear	×	×	×	×
13.	Cervus tarandus—Reindeer	×	×	×	×
14.	Cervus megaceros—Irish Elk... ...	×	×	×	
15.	Bos primigenius—	×			
16.	Bison priscus—Bison	?	×	×	×
17.	Equus caballus—Horse	×	×	×	×
18.	Rhinoceros tichorhinus — Woolly Rhinoceros...	×	×	×	×
19.	Rhinoceros leptorhinus—(Owen) ...				×
20.	Hippopotamus major—Hippopotamus				×
21.	Elephas primigenius—Mammoth ...	×	×	×	× ?
22.	Lepus timidus—Hare	×	×	×	

LIST OF PREHISTORIC (?) AND HISTORIC MAMMALIA OF THE CRESWELL CAVES.

		Pin Hole.	Robin Hood.	Church Hole.	Mother Grundy's Parlour.
1.	Felis catus—Wild Cat		×	×	×
2.	Canis familiaris—Dog		×	×	×
3.	Canis vulpes—Fox	×	×	×	×
4.	Mustela martes—Marten		×	×	×
5.	Meles taxus—Badger		×	×	×
6.	Cervus elaphus—Stag		×	×	×
7.	Cervus capreolus—Roe		×		×
8.	Bos longifrons—Shorthorn Ox ...	×	×	×	×
9.	Ovis—Sheep or Goat	×	×	×	×
10.	Sus scrofa—Pig		×	×	×
11.	Equus caballus—Horse			×	
12.	Lepus timidus—Hare		×	×	×
13.	Lepus cuniculus—Rabbit		×	×	×

ON A GROUP OF ERRATIC BOULDERS AT NORBER, NEAR CLAPHAM, IN YORKSHIRE. BY JAMES W. DAVIS.

At Norber, about a couple of miles E.N.E. from Clapham, there is an immense assemblage of Erratic Boulders, some of immense size, weighing many tons; their peculiar position on the slopes of a high hill, their dark masses, sometimes raised as much as two feet on a pedestal of white limestone, has rendered them striking objects of interest not only to the Geologist, but to all who may have ventured into the wild recesses of the mountains where they are situated. Especial reference was made to these rocks by Prof. Sedgwick in the year 1836, in the Transactions of the Geological Society, and Prof. Phillips has also more than once mentioned them. Hitherto, however, no detailed description has been given of the erratics and the phenomena attending their displacement from their original bed and subsequent carriage and redeposition in their present situations. I purpose in this paper to give as full an explanation of these subjects as I may be, first considering the general characters and the Geological constitution of the surrounding district; and secondly, the nature of the erratics, the source from whence they were derived, and the agency by which they were carried and placed where they now occur.

Norber is surrounded on the north and westwards by some of the highest mountains in England. Immediately behind it rises the mighty mass of Inglebrough, with Whernside beyond. To the westwards are Moughton Fells, separated only by Ribblesdale from the giant forms of Penyghent and Fountains Fell. Southwards is the broad valley of the Wenning, beyond which rises the hills of Brown Moor and Bowland Knotts. The character of the scenery on either side of a line drawn from N.W. to S.E. and running from Ingleton a little south of Norber and along Giggleswick Scar to Settle is very different. This is the line of the great Craven Fault, on the southern side the strata are composed of Millstone Grits, and at Ingleton the Coal Measures are present; the scenery is comparatively flat and tame, covered up to a great

extent with rounded hillocks left by glaciers which once extended from the hills far down into the plains. On the northern border of the Fault the scenery is grander and bolder. Immense white scars of Mountain Limestone rise tier above tier with intervening flat surfaces of weather-worn limestone "pavements," the cracks and fissures in which afford shelter and nourishment to a few hardy plants,—the only signs of life which are to be found. There is an unbroken thickness of 500 or 600 feet of the limestone, compact, somewhat prismatic in structure, and light grey in colour. It forms a great plateau entending beneath Ingleborough, Penyghent, Whernside, and the other high hills of the district. In the deep vallies at the foot of the hills at Ingleton, Clapham, Crummack, and Ribblesdale, the thick Scar Limestone is seen to rest on the upturned and contorted edges of the grits and slates of the Silurian system. Very fine sections shewing the junction of the two groups of strata may be seen at Thornton Force, in Kingsdale, in Crummack-dale, and under Monghton Fell, in Ribblesdale. In each case the Silurian rocks are folded into a series of anticlinals, the upper surfaces of which have been ground down to a nearly level plane before the limestone became deposited above them.

Besides the great fault named above, there is a second important fault branching from it near Clapham, which passes the foot of the escarpment at Norber, along the valley between Monghton Fell and Feizer, and thence along the Stainforth Scars to Malham Tarn. This fault brings the limestone of Giggleswick Scar down to the level of the Silurian rocks of Monghton Fell in a deep valley extending westwards from Helwith Bridge in Ribblesdale to Wharfe on the Austwick Beck, a tributary of the Wenning. A branch from the Austwick Beck draining this cross valley rises at a less distance than half-a-mile from the river Ribble, a very slight rise in the surface of the ground forming the water shed between the two streams.

Norber is the southern extremity of a long promontory of the Mountain Limestone, extending from the base of that portion of Ingleborough called Simon's Fell. On its western flank are

escarpments overlooking Clapdale, and on the opposite one precipitous ridges extend for nearly two miles in a northerly direction towards the head of the dale, overlooking the Crummack valley. The escarpments of the limestone extend across the upper part of the dale, and on its eastern side constitute the rugged scars of Monghton Fell. Except on the Norber side, where a plateau of the limstone, considerably below the summit of the hill, and near the base of the limestone, extends across the valley to about $\frac{1}{3}$ its width; the whole of the surface of the valley lower than the limestone escarpments is composed of Silurian grits and slates. The latter form two or three anticlinals extending across the valley; the whole of the limestone which formerly overlaid them having been denuded and removed, probably long before the period when glaciers descended the valley of which we are now speaking. Referring to the plan (plate XIV,) the whole of the surface of the upper part of the valley to the base of the Limestones is composed of Silurian rocks. At A, which is the primary source from whence the boulders strewn over the surface southwards have been derived, the rock is a massive thick-bedded grit forming the summit of an anticlinal, extending to, and exposed at A1. Near this point is the lime kiln marked on the survey map. Westwards the ground rises very rapidly in the direction of B, and the Silurian rocks dip at a very sharp angle to the N.E. By tracing these beds towards the upper part of the valley, it will be seen that they form a synclinal, and in about 150 yards again double over, forming an anticlinal.

On the opposite side of the valley under the precipitous scars of Monghton Fell, the whole of the limestone has been denuded, and there are several exposures of the Silurian rocks, approaching more or less to the vertical, as at C and D on the plan, near Southwaite and as far south as the village of Wharfe; beyond this point the Silurian rocks appear to be cut off by the northern branch of the Craven Fault. From A southwards the surface of the ground gradually rises, forming a plateau which extends to

the parts marked E, E1, E2, and is almost entirely made up of Mountain Limestone. Towards the S.E. it terminates in a bold escarpment which is continued westwards and overlooks Clapdale. This plateau constitutes a base from which rises other escarped beds of limestone to the height, at F, of about 1300 feet above the sea level.

The whole of the surface of the limestone plateau between A, E, and F, is thickly strewn with masses of Silurian Grit, some of these are of immense size, and weigh many tons, Blocks 16 to 20 feet in diameter are not uncommon, some are so perched on the underlying limestone as to form rocking stones. These masses of rock are generally quite angular in form, and do not exhibit any scratches or marks of glaciation; they are frequently split and broken in various directions by subærial agencies. In numerous instances the grits have served as a protection to the limestone beneath them, and they are now supported on limestone pedestals 18 to 24 inches in height. This circumstance leads naturally to the inference that, since the period during which the Silurian rocks were carried and deposited where they are now found, the surface of the limestone has been lowered, except where protected by the overlying masses of Silurian rocks, to the extent of nearly two feet; and considering that this large amount of denudation is entirely due to the subærial agencies of rain, frost, and wind—whose action is very slow—there must have been a lapse of time of great length since the Erratics were carried to their present resting place.

The boulders are ranged in three directions or streams. The principal one extending from A to E, and E1 has been derived in a great measure from the thick bedded grits exposed *in situ* at A. The latter position is 900 feet above the sea level; the ground rises to E1, where the abrupt escarpment ending the plateau is 1050 feet in height. Immense masses of the rock are laid immediately in front of the parent ridge at a much lower level, and the direction and progress of the glacier which tore them away and carried them forward is clearly shewn by the great blocks

which occupy all the rising ground for a distance of nearly a mile. The largest erratics are found in this direction, and altogether the force appears to have been greatest along this line. At the source of the boulders A, there are great masses of the grit, in part broken away and ready for transportation, just as so many masses had been carried before them; and amongst these are a few large blocks of limestone, brought from a distance behind, and left by the ice on the gritstone surface. At the opposite extremity of the limestone plateau, its scarped edges are surmounted by numbers of the Silurian boulders, standing, when looked at from below, black against the sky, with the white horizontal beds of limestone beneath; many Erratic blocks have fallen over this edge of the cliff, and lay scattered on the slopes below, and extend in gradually diminishing numbers over the meadow lands in the direction of Austwick and Clapham, some of them on the site of a small lake which was drained only a few years ago. A number of the boulders have assumed picturesque forms, due partially to the weathering of their own surface, but more so that of the limestone underneath them. Occasionally a great block stands on a small pillar; others are so balanced that they will rock and sway with a slight push, or are perched on the edge of the escarpment so that they appear almost incapable of resisting the action of a strong wind.

A second stream which occupies the higher ground to the west, appears to have had its origin in several beds of Silurian rocks at B. Evidence of the intense pressure of the grinding mass of ice is afforded by the surface of the grits being broken into thousands of small pieces, along what seem to be lines of cleavage at right angles to the plains of bedding or deposition, here dipping about 45° N. The ice which transported the blocks of gritstone along this side the valley has been forced along the hill side, and towards F reached a height of 1200 feet; a much higher elevation than any other where boulders have been left by these glaciers. The Erratics are strewn for nearly a mile along the upper slopes of the hill side. The glacier bearing them entered

a bay-like hollow in the escarpment of limestone above, at G, and has pressed over the succeeding promontorys, and left a few large, and an immense number of smaller masses perched on the limestone pavement, or scattered in the clefts of the rock, into which they have since fallen. Many lie partially buried in the turf and herbage where it occurs. The course of the ice was continued at a height of about 1200 feet round the highest part of the hill F, but does not appear to have passed over it; there being no Silurian Erratics or other indications of its presence on the top, which is 100 feet higher. There are several masses perched on the slope of the hill side to the westwards; and a considerable number lay scattered over the lower ground southwards in the direction of Clapham, the pastures in which the boulders are laid, being about 700 feet above the sea level.

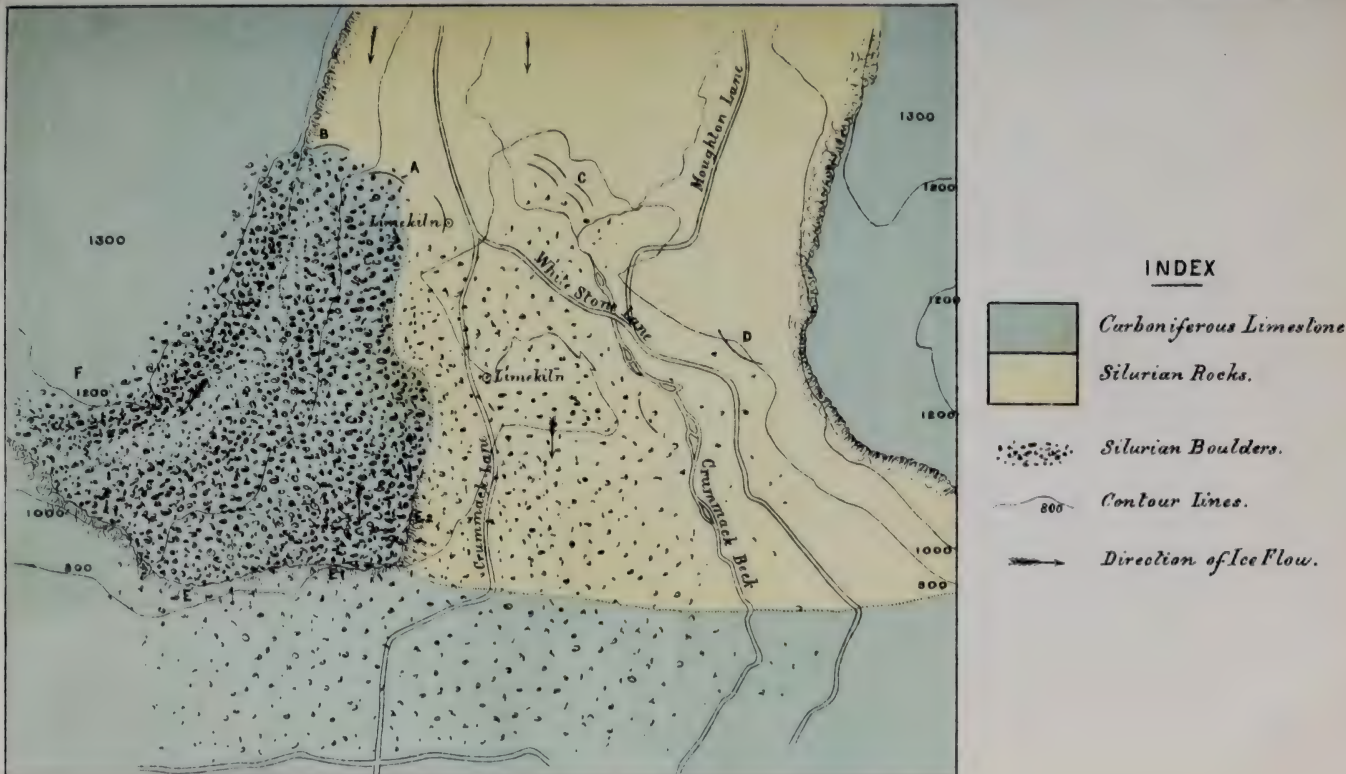
The boulders on the Monghton side of the valley are neither so numerous nor important as those already described. They have been obtained from the Silurian rocks at C and D. It is probable that the boulders were formerly much more abundant than at present. The land is, for the most part, under cultivation; and the boulders have been broken up and removed. Many, no doubt, have been used in building the fences or walls dividing the fields,—they are almost entirely built of Silurian grits and slates, with occasionally a large boulder of the same material for a foundation.

The careful labours of Messrs. Tiddeman, Dakyns, and Goodchild in mapping the scratches which have been observed on the rocks of the Yorkshire dale district and the adjacent country, render an explanation of the Phenomena observed at Norber tolerably easy. An immense glacier descended from Scotland across the Solway Frith, pursuing a southerly course it passed along the Eden valley at the foot of the Cross Fell escarpment. Still continuing southwards the glacier received considerable accessions of ice from the mountains of Westmoreland and Cumberland. A part of the glacier branched off over Stainmoor into Yorkshire and Durham, whilst the principal mass persued a course

down Lune Dale and towards the Irish sea; on the one side Howgill Fells, and on the other—descending the valley in which was the river Rawthey—between the Howgill Fells and Baugh Fell. Another branch of this great sheet of ice ascended Mallerstang and passed over the watershed of the Eden at Lunds, descended into Garsdale, and crossing the eastern spur of Rysel descended into Dentdale; thence the course of the moving mass of ice appears to have been westwards of Whernside, over Bleamoor and along the limestone plateaux of the Ingleton Fells. A few miles southwards the glacier was divided by the slopes of Ingleborough; the westerly division passing down Dale beck, and the eastern passing for the major part into Ribblesdale; being deflected to a more easterly direction by the great spur from Ingleborough, Simon's Fell. Scratches along the route are not uncommon, and have been found on the slopes and summits of the mountains to a height of more than 2000 feet. On Simon's Fell scratches have been seen by Mr. Tiddeman at a height of 1225 and 1350 feet. These have a general north and south direction, curving in a direction parallel with the form of the mountain. It is evident that the scratches were not made by glaciers descending Ingleborough, or they would have indicated that the ice was travelling in an easterly direction. If it be accepted that the glacier was pursuing a southerly course as indicated above, then the glacier must have extended across the Ribble Valley to the foot, and a long way up the sides of Penyghent; this gives a breadth of 7 or 8 miles with a thickness of 750 feet. Several scratched rocks occur on the eastern side of the Ribble valley up to a height of 1300 or 1400 feet—about the same height as on Ingleborough.

As the glacier or ice-sheet descended southwards it is probable that it would be divided into two parts by Monghton Fell, (1402 feet); the easterly one passing down Ribblesdale; whilst the westerly one passed into Crummack valley and over the limestone plateau of Norber—about 900 to 1100 feet above the sea level—and thence into the broad valley of the Wenning and its tributaries. It was during the passage of the ice down Crummack valley that

A. Megson Litho. Leeds



Sketch Map of the Distribution of Boulders at Norber.

the Silurian rocks exposed in its lowest part were torn away from their beds and carried up the slopes of Norber and redeposited in many instances 200 or 300 feet above their original position. The Silurian rocks form a series of anticlinals along the valley; these exhibit very clearly the action of the ice. They have a rounded smooth surface very different to the sharp angular blocks which have been transported by the ice. In some instances where the stone has been preserved from the weather, beautifully striated surfaces may be found. Such a one occurs about a hundred and fifty yards north of the bed of thick grit which supplied the principal stream of boulders. The scratches on the grit are deep and well preserved; they point directly south to the part marked A on the map. The weight of the superincumbent ice and the force it exercised in tearing away block after block of the grits, very many tons in weight, often 20 to 30 feet in greatest diameter, and carrying them up the opposite hill, is truly astounding.

In conclusion, the multitudinous aggregation of Erratic boulders at Norber, and their large size, required for their transport an agent of great power and irresistable force. This could not have been supplied by a small local glacier, but the great ice-sheet descending from the north, filling up all the valleys, reaching far up the sides of the highest mountains, and enveloping the whole country in its icy pall to a height of hundreds of feet, is an agent sufficiently powerful to explain all the phenomena under consideration. Descending from the high limestone plateaux of Ingleborough into the Crummack valley, the rough edges of the contorted Silurian rocks were smoothed, polished, and rounded, and their surfaces scratched by the ice during it passage. A little further south the jointed masses of the Silurian grits were torn from their beds, and carried and pushed forward up the opposite hill to Norber, and beyond its extent far into the valleys round Clapham. Eventually the glaciers retreated, and left the boulders scattered in every direction, high on the hill sides to the westwards, covering the limestone slopes of Norber, and extending far to the southwards over the lower ground beyond its escarpment.

ON THE JUNCTION OF THE PERMIAN AND COAL MEASURES, AT CONISBOROUGH.

BY ROWLAND GASCOIGNE, F.G.S.

THE Section to which this Paper refers has been fully described in the Geology of the Yorkshire Coal Fields, (Memoirs of the Geological Survey of England and Wales) p. 479.

A description may also be referred to in "West Yorkshire," p. 183.

ON A CHEMICAL METHOD OF DISTINGUISHING BLACK OBSIDIAN FROM BLACK BLAST FURNACE SLAG.

BY W. H. WOOD, F.C.S.

THE Sileca was determined in a piece of obsidian furnished by Mr. A. Campbell, Curator of the Halifax Museum, and in a black slag from the Low Moor Iron Works, with the following result.

	OBSIDIAN.	SLAG.	
Silica	71·242	39·326	per cent.

The large difference in the amount of this constituent suffices to distinguish the two substances.

A partial analysis of the slag gave the results in column I, for comparisons sake an analysis of a slag by Erdmann, quoted in "Greg and Lettsems Minerology," page 131, is given in column II.

	I.	II.
Silica	71·242	74·80
Ferric Oxide and Alumina ...	12·444	14·43
Lime	4·388	1·96
Magnesia	0·015	0·90
Potash	4·160	6·40
Manganese	Trace	1·31 with Fe O.
Soda, Water, &c.	undetermined	—

The specific quantities of the obsidian and the black slag analysed, were found to be—

Obsidian	2·60
Black Slag	3·07

ON TRACES OF ANCESTRAL RELATIONS IN THE STRUCTURE OF THE ASTEROIDEA. BY W. PERCY SLADEN, F.L.S., F.G.S.

[Plate XV.]

THE Echinodermata constitute a sub-kingdom of animals in which the structure of the various divisions presents a number of highly remarkable points of affinity and difference. Indeed, so strikingly is this the case, that when typical or representative specimens are subjected for the first time to superficial examination by a person unacquainted with their internal anatomy, the principal groups would most probably be looked upon by him as perhaps the most diverse of creatures—popularly speaking—that it could be possible to link together. Five Classes of living Echinoderms are included in this category:—

1. The *Crinoidea*, which are familiarly known as 'Sea-Lilies.'
2. The *Ophiuroidea* or 'Brittle-Stars.'
3. The *Asteroidea* or 'Starfishes.'
4. The *Echinoidea* or 'Sea-Urchins.'
5. The *Holothuroidea* or 'Sea-Cucumbers.'

The present communication will deal with certain homologies that exist in the structure of the *Asteroidea* and *Ophiuroidea*, upon which deductions of considerable importance have been based. It will be desirable, however, to explain before proceeding further that although the word 'homologies' is employed in this instance as synonymous with 'traces of descent,' it is not the purpose of this paper to trench upon the subject of the phylogenetic development of the Echinodermata as a whole, but simply to confine the remarks to several points of evidence that indicate ancestral relations between the two groups in question.

Although we shall not directly press into our service palæontological evidence, I make bold to believe that the subject will not be without interest to Geologists;—first, from the circumstance that Asteroids and Ophiuroids are amongst the earliest representatives of the Echinodermata with which we are acquainted; and secondly, because the facts about to be enumerated encroach upon one of

those border-lands that stand between neighbouring classes, and which from the very nature of their being, reflect to us some traces of the structure of ancestral forms that have long since passed away, or even of architypal phases with the actual persons of which we are altogether unacquainted.

It will not perhaps be unprofitable to describe briefly and in plain words for the benefit of those who may not be acquainted with this branch of Zoology, the general appearance and character of the two sets of animals of which we are about to treat.

The Asteroidea or Starfishes possess a more or less depressed body, which may vary in outline in every conceivable degree between a goniodiscoid or pentagonal form, and a deeply indented or truly stellate form. The shape is maintained by a more or less compact frame or meshwork of calcareous pieces, over which is stretched a coreaceous skin, and which, in the generality of cases, is beset with a number of projecting spinelets or prickles. The mouth is situated in the centre of the under surface, and a deep furrow proceeds along each of the radii or 'arms,' as they are familiarly called. When the animal is alive and in health there may be seen protruding from either side of the median line of this furrow, a long continuous row of white pellucid sucker-feet, with which the starfish crawls along. This area of the ray has been named the *ambulacrum* or ambulacral area, and the tube feet, the 'ambulacral suckers.' On making a dissection of a starfish it will be found that the stomach not only occupies the central part of the animal, but also that a portion of it, as well as of the digestive organs and other viscera, is extended along the rays or arms.

Comparing now the Brittle Stars or Ophiuroidea, (which were so named from the long serpent-like arms they possess), we find a small depressed discoid body to which five or more long, worm-like, segmented appendages or rays are attached; the disk being closely tessellated with scale-like plates and the rays being covered with four longitudinal series of large symmetrical plates, of which the lateral ones bear spines. The mouth is situated in the centre of the under surface of the body-disk, but there are no ambulacral

furrows along the rays and no sucker feet, only a pair of small semi-retractile tentacles to each joint, which have little or nothing to do with locomotion; that function being performed by the specially-adapted, slender, flexible arms themselves. The internal anatomy presents still more striking differences, for the stomach is a simple sac confined entirely to the disk, and no prolongations of it in the form of digestive organs or other viscera are extended into the ray; the interior of the ray being occupied by a great number of vertebra-like joints: the whole arm forming a truly independent appendage to the disk, instead of being an actual lobe of the body as is the case in starfishes.

With this introduction we may now proceed to compare the special structure of what is generally regarded as a typical Asteroid with a typical Ophiuroid.

The diagram given on Plate XV., Fig. 1, represents a transverse cut through one of the rays of a starfish. The section of the ambulacral furrow may be recognised on the lower margin, and it is now seen that this furrow is bounded, or indeed formed, by a calcareous arch, (marked *a*). This, however, is not a portion of a solid continuous roof or groove, as might naturally be supposed from such a drawing, but simply represents the end view of a pair of thin lamelliform plates: the length of the ray being built up of a great number of such pairs of plates placed end to end the whole way along. These plates are known as the 'ambulacral plates,' and between each neighbouring pair, a pair of the ambulacral sucker-feet take their passage, (Fig. 1, *t.*). The manner in which these organs are worked is very interesting, and takes effect in the following way:—On the upper surface of the disk-portion of a starfish a small round body may be seen, intersected by a number of fissures and resembling in miniature a brain- or madrepore coral. Through this sea-water passes freely, and traverses a filtering tube until it reaches a vein that encircles the mouth; branches are given off from this oral vessel opposite each ray and proceed along the median line of the furrow; small transverse veins being given off from this main trunk between each pair of

ambulacral plates, and these open into the upper bag-like portion of the sucker feet,—which latter may be described as simple sacs, having very extensile and strongly muscular walls. It will thus be seen that the whole system of vessels is filled with fluid ; and this is known as the 'water-vascular system.' (Coloured blue in the diagram.) When the starfish wishes to extend its sucker, muscular pressure is exerted upon the bag-like portion of the sac ; this causes the contained water, and with it the tentacle-foot, to be squeezed forwards in consequence of the contraction of the reservoir-bag. When it is necessary to retract the foot, the reverse of this process takes place. Returning to the section,—at the outer extremity of each ambulacral ossicle is a small plate (Fig. 1, *b.*), and the series of these form the margins of the furrow. They are called 'adambulacral' plates, and usually carry spines. The sides of the ray are occupied by the lateral or marginal plates (Fig. 1, *l.*), which may be two in number or many ; and the upper portion by the dorsal plates. which are usually arranged in a more or less regular meshwork, and bear clustered spinelets or 'paxillæ' (Fig. 1, *p.*) The internal cavity is extensive, and in it are disposed the digestive cæca previously mentioned. The main radial nerve-cord is situated superficially to the water-vascular vessel, and its position is indicated in the diagram in red.

It will not be necessary for the present purpose to go more minutely into the anatomy of the Starfish, we will therefore proceed to compare a similar section made through the ray of an Ophiuran, which is given in Fig. 2. Here it will be observed that the outer walls are formed by four large plates, and what we see in the diagram are the ends of these plates which constitute the annuloid segments of the ray ; the whole space within, excepting only a very small cleft above and below, being occupied by the extensions of a large calcareous disk, marked *a.*, (Plate XV., Fig. 2), presenting various articulatory prominences and depressions, and which, when the upper arm-plate (Fig. 2, *c.*) is removed, will be seen to be the extremity of a vertebra-like joint, which articulates with a similar body that occupies the neighbouring segment. On

examining one of the segments on the under side, after the under arm-plate (Fig. 2, *d.*) has been removed, it will be seen that the ambulacral tentacles are situated in a pair of quite small pits, excavated, as it were, out of the joint itself. The size of these cavities limiting, as a matter of necessity, the capability of the retraction of the tentacle to such an extent that they can never be entirely drawn in. The vessel of the water-vascular system is situated in the angle of the inferior notch, and the nervous system is placed external to this. (These systems being coloured blue and red respectively.) The internal axis of each joint is attached to that of the neighbouring segment by very largely developed muscular bands.

It now remains to point out the homologies that exist between the structures just passed in review.

If one of the axial joints from the ray of an Ophiuran be carefully examined, it will be seen that this vertebra-like body is in reality formed of two pieces ankylosed together along the median line. (The plate marked *a* in Fig. 2 being one half.) These two plates are in fact the greatly developed and modified representatives of the ambulacral plates of the Asteroid (Fig. 1, *a.*). The side arm plates (Fig. 2, *b.*) are the homologues of the adambulacral plates (Fig. 1, *b.*); whilst the dorsal or upper arm-plates of the Ophiuroid (Fig. 2, *c.*) stand in the place of the dorsal and lateral plates of the Asteroid (Fig. 1, *l*, *p.*). One other plate yet remains to be mentioned (Fig. 2, *d.*), and it is perhaps the most interesting of all, because entirely wanting in the diagram of the starfish. In the latter the ambulacral furrow, with its contained water-vascular and nervous systems, is quite open and uncovered; in the Ophiuran, on the other hand, it is enclosed entirely by the ventral or under arm-plate (Fig, 2, *d.*). To account for such a discrepency would be a difficult task, if light were not thrown upon the subject by the embryology of Asteroids; and we owe the discovery to Mr. Alex. Agassiz* that a similar calcareous plating is present along the furrow of a starfish when in a very early phase of growth. This formation, however, becomes so modified during the process of development, that all

* Mem. Mus. Comp. Zool. Harvard, vol. v., pt. 1.

traces have entirely disappeared long before the adult stage is arrived at.

It will be unnecessary for me to point out to those acquainted with the general principles of Biology, the significance and extreme importance of this fact; and it will suffice to say for the present occasion, that this devolves upon a law in embryology—that the phases in the individual development of a complex organism represent, in a more or less epitomised manner, the conspicuous characters of the stages passed through during the course of phylogenetic development, or in other words, symbolise the race-history of the animals to which they belong.

From the above-mentioned circumstance we reason that there was a time in the history of Asteroids when under arm-plates *were* possessed, and when in fact these Echinoderms were conformed to that plan of arrangement which we now associate with the Ophiuroidea only.

The homologies of parts just enumerated may be further pursued if we study the comparative anatomy of the mouth-armature of the two groups, and this investigation will at the same time furnish a proof of the correctness of the foregoing assertions. Such a circumstance is not difficult to understand when it is borne in mind that the mouth-parts are formed by the concrescence and modification of certain of the ray elements; and secondly, that representative elements, or in other words, homologous parts go to the formation of similar portions of the dental apparatus in both groups. As the discussion of this question in detail would absorb far more space than the present occasion would allow, I shall not extend my remarks further in that direction, having simply mentioned the fact as an evidence of the close affinity that may be traced between these apparently widely separated forms.

There is yet another point in the structure of the Asteroidea which ought not to be passed over when critically discussing the race-history of the group; and it is also an embryological observation for which we are indebted to Mr. Alex. Agassiz*; although I

* Proceed. Am Acad. Arts and Sci., April, 1863.

am not aware that that naturalist has availed himself of the deductions which necessarily follow. When describing the Starfish it may be remembered that I drew attention to the presence of a peculiar madreporiform body, situated between the margin and the centre, on the upper or *dorsal* surface of the disk, and which formed the orifice of the water-vascular system. In the Ophiuroidea the position is altogether different, the orifice being found on the *ventral* or under surface and occupying one of the plates that surround the mouth. Now in this very striking difference there lies—although it may seem strange at first thought—a highly important point of evidence in support of the argument which this paper maintains.

In an early stage of the development of an Asteroid, shortly after the young starfish larva has emerged from its *brachiolaria* phase, the plate that bears the punctures of the water-vascular system, and which eventually becomes the madreporite, is situated on the *under* side, and close adjoining the plates that form the margin of the mouth. In other words, we have again presented to us in the larval Asteroid, the precise arrangement of parts that occurs in the Ophiuroidea when in the mature form ; and from this we are led to infer from our present knowledge of the laws of embryolcgy, that the Asteroidea have in the course of the history of their race, passed through a stage which is now represented—in a more or less modified style, it may be—by the present Ophiuroidea.

Notwithstanding the existence of these resemblances in structure, it has always been held that the Asteroidea and Ophiuroidea were separated by a wide gulf of difference, over which no known echinoderm presented sufficiently modified characters to form a bridge, and which would serve as an index of their closer ancestral alliance. Recently, however, there has been discovered a remarkable organism of most abnormal form, undoubtedly intermediate between the two groups, and which passes unquestionably very much further over the borderland that lies between them than any other star fish or brittle-star with which we have hitherto been acquainted.

Space will not permit me to enter further into the description of this curious organism, than to say that it appears to present the

general character of ophiuran structure, arranged and modified according to the plan of asteroid organization, and in this manner to reflect as it were, a primitive stage of the race-history of the classes which we are discussing. There exists, however in the anatomy of *Astrophiura*—for such is the name under which I have described* this aberrant genus—a feature that bears so strikingly upon the subject with which we are dealing, that it will be found not unworthy of attention whilst we touch upon it very briefly.

The diagram given in Fig. 3, represents a section through one of the radii. On comparing this with those which we have previously been considering, it will be seen we have here a sort of compromise between the characters of both. In a modified form there is the internal skeleton belonging to the Ophiuroidea, together with the presence of the peritoneal cavity which is found in Asteroidea. The radial axis however is extremely aborted, and the disk-like processes, which in the Ophiuroidea extend from side to side across the section of the ray, are here reduced to diminutive ear-shaped processes of the most insignificant description. (Fig. 3, *a.*)

Furthermore, there exists a supplementary plate in *Astrophiura* (Fig. 3, *e.*), and upon this especial interest devolves. It consists of a large, broad, thin plate, that joins up to the aborted disk-processes of the axis and forms a partition reaching up to the inner surface of the abactinal wall of the test, constituting in fact the divisional septum, or wall of a compartment, for an ambulacral tentacle. No equivalent for this accessory plate can be pointed to in the section of the typical Ophiuroid, and search has to be made amongst the Asteroidea before any homologous structure is met with. In the more ancient forms of that group, such *e.g.* as the *Astropectinidæ* and *Linckiadæ*, a small supplementary plate occurs, which forms a connective or intermediate piece, filling in the angle formed by the ambulacral and ventro-lateral plates. (Fig. 1, *e.*) These are what I consider to be the homologues of the supplementary plates or ambulacral septa just mentioned in *Astro-*

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* Proceed. Roy. Soc., vol. xxvii, p. 456. Ann. and Mag. Nat. Hist., ser. 5 vol. iv, p. 401, pl. xx.

phiura. If this view be correct, the main interest will centre in the fact that we have here the representation of a stage in the genetic developement of the Asteroidea, all traces of which have passed away in the course of the evolution of the more advanced forms of the group.

In conclusion,—the details of structure which have been brought forward require but very few words in the way of summing up. The facts speak for themselves, and, if we take a common sense view of things, the conclusion seems inevitable that the homologies now adduced indicate the existence of an ancestral relationship between the two groups in question ; nay more, they point to a common origin or start-point of descent. From our present knowledge it would be difficult, it is true, to demonstrate definitely the actual line by which the Asteroidea have descended from Ophiuroidea, such as those at present known to us, but I submit that this much may be predicated with but little hesitation, —that both Asteroidea and Ophiuroidea are the descendents, (along collateral lines of development), from a more remote and common Ophiuroid-like ancestral stock, but with the actual form of which we are at present altogether ignorant, and of the probable structure of which we are only able to surmise.

Bold though such a statement may seem to some, I feel confident that biologists will grant that the nature of the evidence is such as to remove this conclusion from the region of mere vague speculation, and to place it upon the basis of warrantable generalisation.

EXPLANATION OF PLATE XV.

Fig. 1.—Section through the ray of an Asteroid *(Astropecten)*, at the junction of two segments. Magnified and partly diagrammatic.

a. Ambulacral plate.

b. Adambulacral plate. This plate bears the 'ambulacral' spines, which have been omitted from the diagram for the sake of clearness.

e. Supplementary girder-like plate.

l. Lateral plates. These plates usually bear spines, which have been omitted from the diagram.

p. Paxillæ of the dorsal area.

t. Ambulacral tentacle or sucker-foot.

FIG. 2.—Section through the ray of an Ophiuroid *(Ophiarachna)*, at the junction of two segments. Magnified and partly diagrammatic.

a. Disk of the axial skeleton of the segment.

b. Side arm-plate. This plate bears the arm-spines, which have been omitted from the diagram for the sake of clearness.

c. Upper arm-plate.

d. Under arm-plate.

t. Ambulacral tentacle.

FIG. 3.—Section through the ray of *Astrophiura*, at the junction of two segments. Magnified.

Same letters as above.

In each of the figures homologous parts are marked with the same letters.

The Water-vascular system is coloured blue, and the position of the Nervous system is indicated in red.

ON THE GEOLOGY OF THE DISTRICT OF AROUND MIDDLESBOROUGH. BY W. Y. VEITCH. (ABSTRACT.)

This Paper was of the utmost service to the members who attended the meeting at Middlesborough, and contains a clear account of the Geology; with remarks on the Flora of the District. There is however not sufficient new matter to render its publication necessary.

THE town rests upon an estuarine deposit consisting of clay, sand and gravel, with patches of a peaty nature distributed in low-lying places, containing much vegetable remains, large trunks of oak, a few antlers of the red deer, and numerous shells of the Scrobicularia piperita.

A staple going 27ft. below low-water mark, at the new gas tank, revealed nothing but layers of soft blue clay mixed with vegetable matter, and a loamy mixture of silt clay and vegetable matter. Below this is the new red sandstone containing enormous deposits of salt, upwards of 100ft. in thickness, at a depth of about 400 yds. At high water the low-lying places referred to are saturated subterraneously with water, which again disappears with the receding tide.

A. Megson Litho. Leeds

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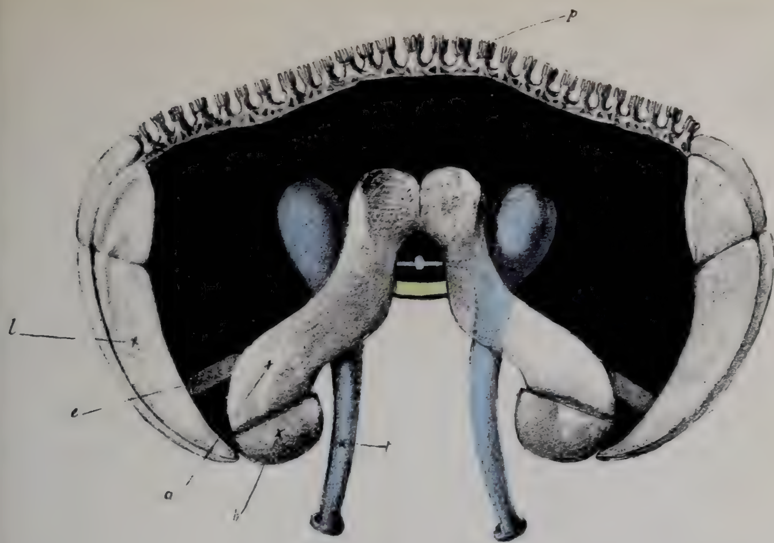

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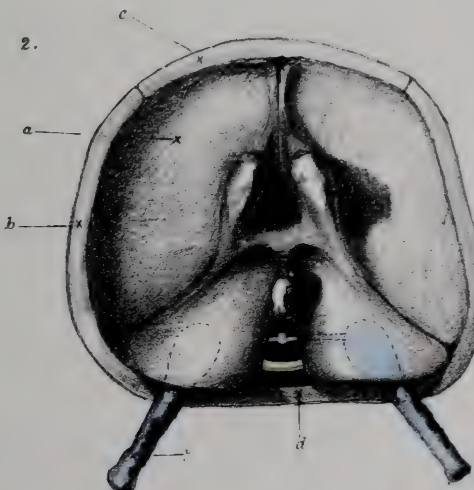

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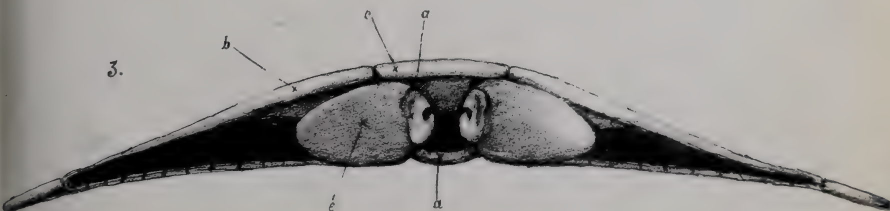


Henry Sykes, Del.

ASTEROID AND OPHIUROID STRUCTURE.

NOTES ON THE GEOLOGY OF THE CLEVELAND DISTRICT. BY THOS. ALLISON.

[THE account of the Local Geology in this Paper is very carefully drawn up, but has already appeared in works and memoirs on the Geology of the District,]

The following Sections may be useful.

SECTION OF STRATA SUNK AND BORED THROUGH AT MIDDLESBRO' BY MESSRS. BOLCKOW, VAUGHAN & CO., BEGUN 4TH JULY, 1859. DIAMETER OF BOREHOLE, 1FT. 6IN.

No.	Strata.	Thickness. Ft.	In.	Depth. Ft.	In.	Remarks.
1	Made Ground (Slag, Chalk, &c.) ...	11	0	11	0	
2	Dry Slime or River Mud	8	0	19	0	
3	Sand, with Water	10	0	29	0	
4	Hard Clay (dry)	10	0	39	0	
5	Red Sand, with a little water ...	1	0	40	0	
6	Loamy Sand	3	0	43	0	
7	Hard Clay (dry)	15	0	58	0	
8	Rock, mixed with Clay and Water	11	0	69	0	
9	Rock, mixed with Clay (dry) ...	1	0	70	0	
10	Rock, mixed with Gypsum (dry) ...	6	0	76	0	
11	Gypsum, with water	2	0	78	0	
12	Red Sandstone, with small veins of Gypsum	55	0	133	0	
13	Gypsum Rock (dry)	6	0	139	0	
14	Brown Shale, with water	1	0	140	0	
15	Red Sandstone	4	0	144	0	
16	Red Sandstone, with small veins of Gypsum and Water	12	0	156	0	
17	Blue Sandstone, with water at bottom	3	0	159	0	
18	Red Sandstone, with water ...	19	0	178	0	Bottom of Sinking Shaft, 1ft. diameter.
19	Red Sandstone	437	4	615	4	Commence Borehole.
20	Red and White Sandstone... ...	1	6	616	10	
21	Red Sandstone	215	7	832	5	
22	Red Sandstone and Clay	1	0	833	5	
23	,, ,, ...	52	3	885	8	
24	Red Sandstone and Clay	9	0	894	8	
25	,, ...	66	5	961	1	

SECTION OF STRATA. *(Continued)*

No.	Strata,	Thickness. Ft	In.	Depth. Ft.	In	Remarks.
26	Strong Clay	2	9	963	10	
27	Red Sandstone and Clay	1	6	965	4	
28	,, ,, ...	27	5	982	9	
29	Red Sandstone and Clay	9	0	991	9	
30	Sandstone, with a vein of Blue Rock	49	4	1051	1	
31	Red and Blue Sandstone	1	5	1052	6	
32	Red Sandstone	6	0	1058	6	
33	Red Sandstone, and thin veins of Gypsum	1	5	1059	11	
34	Red Sandstone, and thin veins of Gypsum	39	8	1099	7	
35	Red Sandstone, Blue Clay and Gypsum	1	2	1100	9	
36	Red Sandstone, with veins of Gypsum	87	3	1188	0	
37	Gypsum	3	2	1191	2	
38	White Stone	0	8	1191	10	
39	Limestone	2	8	1194	6	
40	Blue Rock	0	2	1194	8	
41	Blue Clay	0	2	1194	10	
42	Hard Blue and Red Rock	0	10	1195	8	
43	White Stone	2	7	1198	3	
44	Dark Red Rock	1	2	1199	5	
45	Dark Red Rock, rather salt ...	6	7	1206	0	
46	Salt Rock, rather dark ..	12	7	1218	7	
47	,, ,, very dark ..	4	1	1222	8	
48	,, ,, very light ...	3	6	1226	2	
49	,, ,, rather dark ...	27	4	1253	6	
50	,, ,, very light ...	43	6	1297	0	
51	,, ,, rather light .	9	0	1306	0	
52	Limestone	1	0	1307	0	
53	Conglomerate	6	4	1313	4	This resembles Limestone, and contains a great quantity of salt.

SECTION OF STRATA BORED THROUGH BY THE "DIAMOND DRILL," ON SALTHOLME FARM, THE DURHAM SIDE OF THE TEES. BY MESSRS. BELL BROS., 15TH DECEMBER, 1874.

No.	Strata.	Thickness. Ft.	In.	Depth. Ft.	In.	Remarks.
1	Soil	1	6	1	6	
2	Clay	4	0	5	6	
3	Dark Sand	7	6	13	0	
4	Clean Sand	26	0	39	0	
5	Red Clay	3	0	42	0	
6	Sand and Gravel	8	0	50	0	
7	Boulder Clay	27	0	77	0	
8	Red Marl	73	0	150	0	
9	Red Sandstone with veins of Marl	144	0	294	0	
10	White Sandstone	1	3	295	3	
11	Red Sandstone with veins of Marl	153	9	449	0	
12	Red Sandstone	10	0	459	0	
13	Soft Marl	3	0	462	0	
14	Red Sandstone	6	0	468	0	
15	Blue Vein	0	10	468	10	
16	Red Sandstone	31	2	500	0	
17	,, ,, with veins of Marl	27	0	527	0	
18	Soft Marl	4	0	531	0	
19	Red Sandstone	29	0	560	0	
20	,, ,, with veins of Marl	49	0	609	0	
21	Soft Marl	6	0	615	0	
22	Red Sandstone with veins of Marl	31	0	646	0	
23	,, ,, ...	6	0	652	0	
24	Marl with blue veins of Sandstone	17	0	669	0	
25	Red Sandstone with veins of Marl	66	0	735	0	
26	Blue Vein	0	7	735	7	
27	Red Sandstone with veins of Marl	13	5	749	0	
28	Strong Marl	9	6	758	6	
29	Red Sandstone with veins of Marl	26	6	785	0	
30	Blue Vein	0	3	785	3	
31	Strong Marl	6	3	791	6	
32	Red Sandstone with veins of Marl	30	6	822	0	
33	Strong Marl and Sandstone ...	17	0	839	0	
34	Red Sandstone with veins of Marl	16	0	855	0	
35	Strong Marl	20	0	875	0	
36	Red Sand and Marl	5	0	880	0	
37	Red Sandstone with veins of Marl	14	0	894	0	
38	Strong Marl, veins of Sandstone	6	0	900	0	
39	,, ...	23	0	923	0	

SECTION OF STRATA. *(Continued.)*

No.	Strata.	Thickness. Ft.	In.	Depth. Ft.	In.	Remarks.
40	Strong Marl, with veins of Gypsum	7	0	930	0	
41	Mixed Marl with Sandstone ...	27	0	957	0	
42	Marly Sandstone with veins of Gypsum	141	0	1098	0	
43	Gypsum	4	0	1102	0	
44	Hard White Stone	3	9	1105	9	
45	Gypsum	3	6	1109	3	
46	Marly Sandstone, very salt ...	8	1	1117	4	
47	Decayed Red Marl, with salt ...	10	3	1127	7	
48	Red Rock Salt	9	0	1136	7	40-45 % of salt, only 3ft. of core fresh water being used.
49	Rock Salt	66	5	1203	0	
50	Salt with Marl and Gypsum ...	19	0	1222	0	
51	Gypsum, containing salt	7	0	1229	0	
52	Soft Shale, with Salt and Gypsum	7	0	1236	0	
53	Soft White Shale	2	0	1238	0	
54	Gypsum and Anhydrite	23	0	1261	0	
55	Magnesian Limestone	52	0	1313	0	Liberation of Gas.
56	Grey Limestone	15	0	1328	0	
57	Gypsum	8	0	1336	0	
58	,, containing Salt	1	0	1337	0	
59	Rock Salt	14	0	1351	0	
60	Marl, containing salt	2	0	1353	0	
61	Marl, with Gypsum	1	0	1354	0	
62	Impure Salt	1	0	1355	0	

ON SOME BONES OF CTENODUS. BY PROF. L. C. MIALL.

For many years past teeth and bones of Ctenodus have been accumulated in various public and private collections, and it may be useful to those who possess such collections to set down briefly some of the identifications already made. A short statement of the facts now accessible respecting the organisation of the genus will render it easier to place any newly discovered fragments, and may, I venture to hope, stimulate some of the members of this Society, whose local opportunities are far greater than is at present imagined, to search for fresh materials. The fish-bearing shales of the Yorkshire Coal-field have proved productive of interesting fossils whenever they have been diligently examined, and much yet remains to be dug out and compared—how much a glance at the following very imperfect sketch of one of the most noteworthy and most abundant of Coal Measure fishes will show. The facts here recorded are derived from the examination of specimens belonging to the Earl of Enniskillen, the Natural History Society of Newcastle-on-Tyne, the Leeds Philosophical and Literary Society, J. W. Davis, Esq., of Halifax, John Ward, Esq., of Longton, and T. P. Barkas, Esq., of Newcastle-on-Tyne. I have to thank the owners of these collections for permission to examine their examples of Ctenodus at leisure and simultaneously. Other important collections I have examined in passing, but without adequate time to work up the results in the present memoir. One example at least of each bone figured is contained in one or other of the collections named above. In most cases I have been able to compare several examples and to prepare an outline which, without being in any respect hypothetical, is more complete than the best of the fossils upon which it is founded.

Hinder Part of Skull (upper surface). Several good examples of the ossifications of this region have occurred. The

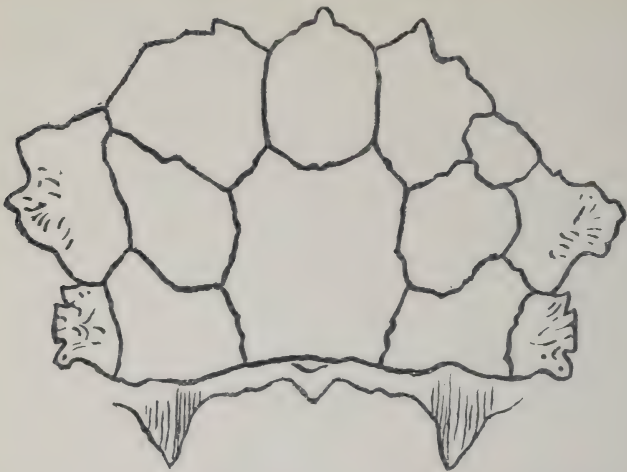


Fig 1.—CTENODUS. Superficial Cranial Ossifications. (Occipital Region). The two sides are drawn from different examples. × ½.

figure shows two slightly different arrangements met with in two different skulls, which possibly belong to two species. Messrs. Hancock and Atthey were inclined to regard such variations as diagnostic of particular species.* I have found them to occur in every skull examined, and so far as a very limited experience is to be trusted at all, it renders improbable any such degree of constancy as would serve to indicate species. The general disposition of the membrane-bones which defended the top of the skull agrees with Dipterus, as Hancock and Atthey have observed; it agrees pretty well with the Sturgeon also, which is here figured for comparison. The nomenclature (parietals, frontals, &c.) applied to bones of the same order in the skulls of higher vertebrates, is not applicable, so far as can be shewn, to Fishes, and since these bones differ greatly both in number and arrangement within the class, it would perhaps be best to avoid for the present any such appropriation of terms to particular ossifications as might imply a well-founded theory resting upon relations of observed constancy.

* Nat. Hist. Trans. N. & D., vol. iv., p. 402.

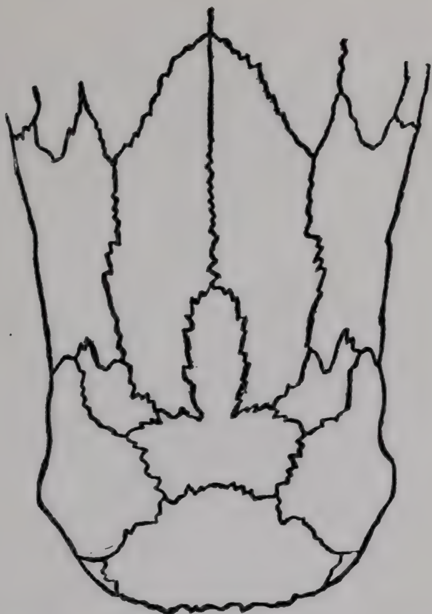


Fig. 2.—ACIPENSER. Superficial Cranial Ossifications. (Occipital Region) × ½.

Palato-pterygoid. This has been figured more than once, and

Fig. 4.—CTENODUS OBLIQUUS. Palato-pterygoids, with teeth. × ½.

its resemblance to the same part in *Ceratodus and Dipterus* has been commented on.* Dr Traquair observes † that the division

* Hancock & Atthey, N. H. Tr. N. & D., vol. iv., p. 405, pl. xiv. T. P. Barkas, Coal Measure Palæontology, Atlas, pl. x., figs. 247, 248. L. C. Miall, Q. J. Geol. Soc., vol. xxx., p. 772.

† Ann. Nat. Hist., 5th ser., vol. ii., p. 6.

of the palato-pterygoid of Dipterus into lateral halves, which was supposed to constitute a difference between Dipterus and Ctenodus, is due to fracture, and has no anatomical or zoological significance. The ossification of the hinder end of the bone is more complete in Ctenodus than in Ceratodus, and it bears what looks like a wide trochlear surface in some well-preserved examples of the former genus, as if it had entered into the articulation of the mandible, investing and replacing the cartilage of the suspensorium to an unexpected extent. That such was really the case, and that the palato-pterygoid formed, or even entered into the joint of the mandible, I think highly improbable, but I have as yet seen no quadrate bone nor any cavity for the cartilaginous suspensorium. Probably the posterior end of the palato-pterygoid curved round the edge of the palato-quadrate cartilage. In Dipterus, as Dr. Traquair shows, there is a bony quadrate, apparently distinct from the contiguous bones, and the skull is autostylic. There is nothing to show that this was not also the case with Ctenodus also.

Parasphenoid. Both upper and under surfaces are figured.

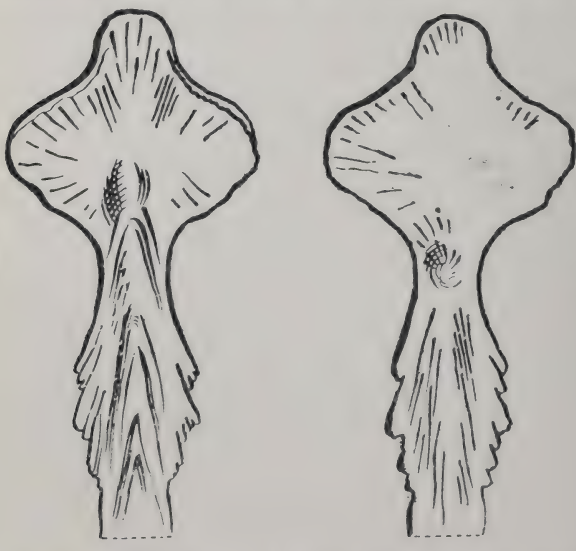
A  B

Fig. 3. CTENODUS Parasphenoid. A, upper surface. B, under surface. × ½.

The best example of a parasphenoid in position which I have yet seen is a Newsham specimen now in the Leeds Museum, which has been figured by Mr. T. P. Barkas * and by myself.† Its relation to the palato-pterygoid is almost precisely the same as in Dipterus

Fig. 5.—CERATODUS. Parasphenoid and Palato-pterygoids, from Günther, Phil. Trans., vol. 161, pt. 2, pl. xxxiv fig. 3 × ½.

and Ceratodus. The broad rhomboidal plate is anterior, and lies between the palato-pterygoids, while the manubrium, or handle, is posterior, extending beneath the skull and probably, as in Ceratodus, underlying the fore part of the vertebral column also.

Squamosal. The bone which I regard as squamosal has

Fig. 6.—CTENODUS. Right Squamosal. × ½.

occurred more than once. The best example I have seen is in Mr. Davis' collection. The long, slender process probably ex-

* Atlas, pl. x., fig. 247.

† Q. J. Geol. Soc., vol. xxx. (1874), p. 772, pl. xlvii.

tended obliquely downwards and forwards on the outside of the suspensorium, while the expanded plate defended part of the side of the head. The squamosal is the bone marked "*d*" in Dr. Günther's figures of the skull of Ceratodus.

This is all that I can positively or even probably identify as belonging to the skull proper, omitting the inferior arches, of Ctenodus. Fragments believed to belong to the interior of the skull exist, and require attention, but so far their connection with Ctenodus requires to be established, and their anatomical features are not elucidated.

Mandible. The splenial and angular elements of the lower jaw have been well figured by the late Mr. Atthey, to whom we are indebted for some first-rate work upon the vertebrates of the coal measures. Examples are plentiful in the collections sent me

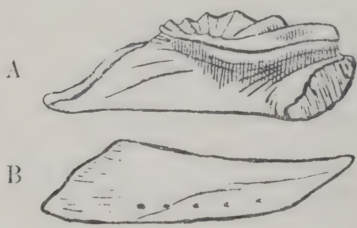


Fig. 8.—Ctenodus obliquus. Left mandible. A, splenial with tooth. B, angular. $\times \frac{1}{2}$.

for examination. The inner piece or splenial ("dentary" of some authors) carries the tooth, and apparently unites with its fellow in a broad and firm symphysis. I find hitherto no indication of a separate dentary bone, such as Prof. Huxley has pointed out in Ceratodus, and Dr. Traquair in Dipterus. The angular bone ("articular" of some authors) lies along the outer surface of the jaw, and was doubtless separated from the splenial in Ctenodus, as in Ceratodus, by a cavity lodging Meckel's cartilage. A row of nutrient foramina (seen in the figure) marks the outer surface; the pointed end is anterior. The best examples of the mandible which

I have had by me are inferior in beauty and completeness to that figured by Mr. Atthey, which, however, it seemed needless to draw again.

Operculum. The operculum in Ctenodus was probably composed of a single plate; at least I have seen no trace of a second

A

B

Fig. 7.—CTENODUS. Opercular. A, *C. obliquus.* B, *C. elegans.* × ½.

opercular bone. Both the outer and inner surfaces are exposed in different specimens, and one fine example, belonging to the Atthey collection, is clear on all sides. On the inner face there is a shallow depression towards the lower border of the bone; this border is stouter than the other, and generally shows a blunt process. The examples figured are one of medium size, (C. obliquus?) and one of small size, (C. elegans.)

Vertebral Column. Vertebral centra, discoidal, of small antero-posterior thickness in proportion to their width, and pierced by central apertures indicating the incomplete ossification of the notochord, often accompany unmistakeable remains of Ctenodus. Hancock and Atthey have described processes, which in one

specimen were found in something like their original position with respect to these centra.*

Ribs. The long, cylindrical and strongly curved ribs of Ctenodus are well known. I can add nothing to the descriptions already accessible.

Shoulder-girdle. The three parts seen in Ceratodus and Dipterus seem to correspond fairly well with the Ctenodus-bones here figured, but I have nowhere found the bones *in situ*, nor have

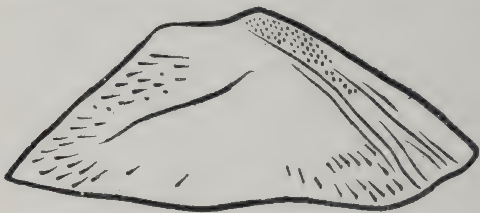


Fig. 9.—CTENODUS. Supra-Scapula. × $\frac{1}{2}$.

I even seen any two in contact. The supra-scapula ("supra-clavicula") was probably loosely connected with the skull, and over-

Fig. 10.—CTENODUS. Scapula. × $\frac{1}{2}$.

lapped by the operculum. The scapula (" clavicle ") had probably

* Nat. Hist. Trans. N. and D., Vol. iv, p. 418.

a loose ligamentous union with the supra-scapula by the superior extremity, while it was firmly united to the third and inferior

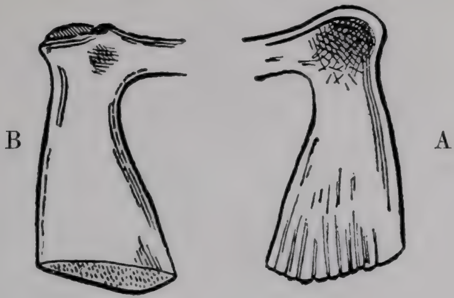


Fig. 11. CTENODUS OBLIQUUS? Coracoid. A, outer surface. B, inner surface. $\times \frac{1}{2}$.

element of the arch (coracoid or "infra clavicle") in the neighbourhood of the glenoid cavity. Indications of this cavity are traceable in some specimens, but the bones are crushed, and give

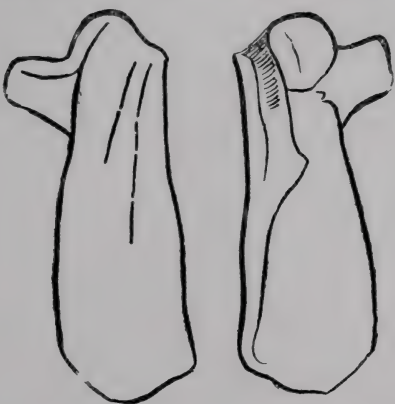


Fig. 12.—CTENODUS CRISTATUS, OF TUBERCULATUS? Coracoid?

no satisfactory details. The scapula and coracoid seem to have been joined at an obtuse angle, the opening of which looked inwards and forwards, while the two coracoids were united along the middle line, meeting at an acute angle as seen in a transverse vertical section.

Bones of the Fins. A crushed bone, which may have been a humerus or femur, has occured, and a smaller but generally similar bone is also known. No specimen which I have seen is at once undoubtedly part of the skeleton of Ctenodus, and instructive as to the osteology of the animal, whether Ctenodus or some other, to which it belonged.

Fin-rays, probably assigned correctly to Ctenodus, have occured, but I am not acquainted with any feature of interest in a well authenticated example. If Dr. Traquair's identification of Campylopleuron with Ctenodus* is well founded, (and this I have no reason to doubt) we learn thereby that Ctenodus had a continuous diphycercal tail-fin, like Ceratodus, and unlike Dipterus, in which last-named genus dorsals and anals are differentiated.

Some of the bones, like the teeth, of Ctenodus are divisible by their size into well-marked groups, which have some probable relation to at least as many distinct species. Thus three species are clearly indicated by the various parasphenoids known, and three by the opercula. Unfortunately, our opportunities of precise information are hitherto so few that we can rarely refer the bones to their species except in this rude way. Judging from occasional juxtaposition with teeth (the parts on which all the species at present recognized are based), and also from differences in the size of the bones corresponding to those which the teeth present, we should refer the fossil remains to three groups of species somewhat as follows :—

LARGE.	C. cristatus., Ag.
	C. tuberculatus, H. & A.
MEDIUM.	C. imbricatus, H. & A.
	C. obliquus, H. & A.
	C. ellipticus, H. & A.
SMALL.	C. elegans, H. & A.

To what extent these and other species which have received names are distinct from each other is a question which I do not propose to discuss here. If decided in our time it must be decided

* Nature, vol. xviii., p. 483. (1878).

mainly by evidence derived from the teeth, which are the only parts sufficiently numerous and sufficiently comparable with each other to yield serviceable characters. The collections now accessible might seem at first sight copious enough to justify a confident opinion as to the number of species which they represent, but after some experience of the Rhætic Ceratodus-teeth, I think a collection far larger than the largest yet made desirable, if not indispensable. Such a collection would pretty certainly contribute intermediate forms, and break down characters hitherto depended upon. Meanwhile I think it best to accept definitely only a small number of species, the most distinct being apparently *cristatus*, *obliquus* and *elegans*. Others, either already named or hereafter to be proposed, will in time take rank with these, but we can well afford to wait till they are sufficiently investigated. The promulgation of new species based upon single examples of teeth is, as a rule, strongly to be deprecated.

The student of Coal Measure Fishes will find that little of what has been written about Ctenodus need engage his serious attention. Agassiz' original description,* and Hancock & Atthey's valuable papers,† are of real interest and value. For comparison with Ceratodus, Dr. Günther's memoir‡ and Prof. Huxley's shorter notice § are indispensable, while Dipterus may be studied in Hugh Miller,¶ Pander** and Traquair.†† Prof. Huxley's sketch of the classification of the Ganoid Fishes,‡‡ though in parts superseded by the increase of knowledge is now as formerly rich in hints and anticipations profitable to the inquirer.

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* Poissons Fossiles, tom. iii.

† Nat. Hist. Trans., Northumberland and Durham, vols. iii., iv., and v. (1868—76). See especially vol. iii., p. 54; vol. iv., pp. 397 and 417; vol. v., p. 227, and the corresponding plates. These papers appeared also in the Annals of Natural History at about the same times.

‡ Phil. Trans., vol. 161, pt. ii., p. 511. (1871).

§ Proc. Zool. Soc., p. 24. (1876).

¶ Footprints of the Creator.

** Ctenodipterinen des devonischen Systems. (1858).

†† Annals of Nat. Hist., 5th ser., vol. ii., p. 1. (1878).

‡‡ Dec. Geol. Survey, pt. x. (1861).

REPORT OF THE RAYGILL FISSURE EXPLORATION COMMITTEE, CONSISTING OF PROF. A. H. GREEN, M.A., F.G.S.; PROF. L. C. MIALL, F.G.S.; JOHN BRIGG, F.G.S.; AND JAMES W. DAVIS, F.S.A., F.G.S., &c., (REPORTER.)

For several years attention has been directed to a fissure or cave in the Raygill Quarries. Originally opening to the surface, the fissure dips down in a southerly direction into the limestone, and during repeated operations of quarrying it has been from time to time cut across on the face of the quarry; each exposure being at a lower level and exhibiting some new phase of character in the composition of its contents. It is stated by Mr. Todd, the manager, that originally and at the surface, the mouth of the fissure was quite closed up by a thickness of several yards of Blue Clay, in which, especially near the surface, there was a large number of pieces of limestone; beneath the blue clay was a bed of yellow clay, and underlying the latter a considerable thickness of laminated clay, which will be mentioned again. In the blue clay near the surface two or three bones were found; these were not preserved, nor was any definite record kept of their situation or occurrence. A reference to the photograph issued by this Society to its members for the year 1875, will shew that the orifice exposed was not very large, being about 8 feet in diameter, and situated much higher than at present. During succeeding years periodical visits have been made to the Quarry, and each time bones and teeth of several animals have been secured, with which a certain bed of sandy loam was replete. The majority of the specimens so obtained have been deposited in the Leeds Museum, but others have found their way into public or private collections.

In October last year, the Annual Meeting of this Society was held at Skipton, and previous to the meeting the members paid a visit to the Raygill Fissure. Before their arrival the Proprietor, P. W. Spencer, Esq., acceding to a request made by

the Honorary Secretary, had excavated a portion of the sandy matrix, and collected from it a considerable number of bones and teeth.

A meeting of the Council of the Society was held on the 10th December, 1879, to consider the propriety of attempting a scientific investigation of the Cave, and it was resolved :—

"That it is desirable that steps should be taken to secure a thorough investigation of the Raygill Fissure and its contents, and that Profs. Green and Miall, and Messrs. Brigg and Davis, with power to add to their number, be appointed a Committee to carry out the exploration."

It was also decided that a special fund should be obtained, entirely separate from the income of the Society, and that so soon as this fund should amount to £50 operations should be commenced. A circular was issued a few days later to the members of the Society and others interested in Cave explorations, with the result that up to the present time nearly £60 have been subscribed. Operations were begun on Monday, June 7th. Mr. Spencer placed at our disposal workmen skilled in the class of work required, and instructed his manager, Mr. Todd, to assist us in every way he was able. The fissure as already observed opened into the face of the Quarry towards the north. The limestone at this part dips at a sharp angle into the hill towards the south. The top of the opening was about 50 or 60 feet beneath the surface of the ground above. The lower part of the opening was about the same distance above the floor of the Quarry. The entrance to the fissure was 27 feet 6 inches in vertical height and 9 feet across. The section in the exposed face of the Cave (June, 1880) shewed the following beds :—

[LIMESTONE ROOF.]

	Ft.	In.
1. Finely laminated clay	9	0
2. Sand, with layers of sandy clay, and numerous angular and sub-angular stones	11	6
3. Sandy clay, with rounded stones	7	0

The uppermost stratum is composed of fine unctuous laminæ of bluish clay, which turns a brown colour with exposure to the atmosphere; between each lamina of clay there is a minute bed of very fine sand, by means of which the clay can be separated into very thin layers of considerable size. The middle stratum of sand contains numerous boulders of stone, mostly sub-angular in form. These, so far as the Committee have had an opportunity of examining them, are composed principally of limestone and grit rock. No bones have been found in this bed. The third or lowest stratum is a brown sandy clay, containing numerous well-rounded water-worn pebbles of limestone and sandstone, apparently derived entirely from rocks occuring in the neighbourhood. Intermixed with these, especially near the base of the section, are numerous bones and teeth. The sands and clays surrounding or forming the matrix of the bones are cemented together, forming a hard mass enclosing the animal remains. The bones for the most part have lost much of their gelatine, and when newly exposed are very soft and friable, and being cemented in the hard enveloping matrix it is rarely that a bone can be secured which is anything near perfect: they split and break in any direction with the matrix, and remain imbedded in it. Both the pebbles, or boulders, and the bones, are dark chocolate in colour externally, merging on black.

The material was removed from the face of the Quarry backwards, and a considerable number of bones were found in the lowest stratum exposed. After penetrating for a distance of 15 feet, the Cave terminated in this direction by a vertical wall of limestone, and from this point the fissure descended almost vertically for a distance of about 27 feet. The limestone, which formed a wall from 2 to 6 feet thick between this vertical fissure and the Quarry, was removed, and the contents of the Cave worked down to a level with the lowered front of the limestone: this method of working has been pursued to the present time. The base of the Cave has been lowered 27 feet, and it extends from the face 19 feet into the limestone. The vertical fissure is filled up for a portion of its depth by bone earth, similar in character

to (3), but towards the bottom there is in front a large mass of yellow clay, with large angular blocks of limestone. The space between this clay and the southern wall is filled with bone earth. At a depth of 3 or 4 feet below the first level of the fissure, or 31 feet from the top of the opening, there was found the broken pieces of the large tusk of an Elephant. There is a large portion of the tusk missing, and though every effort was made to secure the remaing portions, they could not be found. Along with the tusk were numerous other bones of the Elephant,—mostly broken and fragmentary as usual; there were also several large Molars of this species. There were also bones, well preserved teeth, and broken pieces of tusks of Hippopotamus. The teeth of the Hyena were numerous, and in most instances seemed to be those of adult or aged animals, the points being much worn. Several examples of Rhinoceros leptorhinus, and the broken horn of a Roebuck (Cervus Capreolus) were found in the upper part of the Cave. Except the teeth, which are generally in a good state of preservation, the remaining bones were nearly all fragmentary, and so embedded in the hard-cemented matrix, that it is almost impossible to ascertain to what animal they belonged.

Below the vertical depth of 27 feet the fissure branches in two directions. One proceeds eastwards, and is nearly horizontal; it is sufficiently open for a man to be able to creep a distance of 26 feet, when a mass of fallen limestone prevents further progress; but beyond this point he could see a further distance of about 12 or 14 feet. The second branch lies in a southerly direction and appears to fall rapidly; the roof descends and it is quite filled up at a distance of three or four yards. Where the roof and the sides are exposed they shew evidences of abrasion by running water, the surfaces are smoothened and the corners of the limestone rounded off. There is little evidence of stalagmite having been formed. The uppermost layer in the eastern branch consists of similar laminated clay to that which was found uppermost in the part of the Cave which has been worked.

The following section will serve to explain the relative position of the beds hitherto worked. It is a section across the fissure in a north and south direction.

1. Laminated clay.
2. Sand, and sandy clay with boulders, without stratification.
3. Brown sandy clay, with rounded stones blackened, and numerous bones of animals. No stratification. (Bone-earth.)
4. Stiff yellow clay, with large masses of angular limestone.

The bones in No. 3 have always been most numerous towards the front of the opening. No. 4 is the stiff yellow clay, it is about 9 feet thick, and is full of large masses of fallen limestone—angular but waterworn. Mr. Todd says that this yellow clay is very similar to the yellow clay which was found in the upper part of the Cave before the level at which our operations began was reached. The yellow clay extends from near the face of the Quarry backwards for a distance of 18 feet, and behind it the brown bone earth fills up the Cave. The bone-earth in the lowest part worked has yielded several fine specimens. There does not appear to be any difference either in the character of the material or the animal remains found in it, from that higher in the fissure. A nearly perfect tusk of the Hippopotamus measuring 12 inches in length was found in this part. The bones of Hyena, Hippopotamus, Elephant, and Rhinoceros are also tolerably abundant, and in all respects the character of the fauna appears to maintain a similarity thoughout.

Near the bottom of the vertical part of the Cave there has been found the broken antler of a Roebuck very similar, but more perfect, to the one found higher in the Cave; and the molar tooth of a Bear. Perhaps the most important discovery has been the molars of a Lion, Felis leo, var. spelœa.

Note.—Since the foregoing was written, a large quantity of the yellow clay and bone earth have been removed from the lower part of the vertical portion of the fissure, and for a short distance into the nearly horizontal branch, proceeding in an easterly direction. The opening in that direction is large, and contains a quantity of material, reaching almost to the roof of the fissure. Where the

limestone is exposed it exhibits a water-worn appearance throughout the whole of the lower part of the fissure. During the excavation of this part a considerable number of teeth and bones have been found similar to those dug out at a higher elevation.

On account of the bad weather, and the amount of water lodging in the fissure, the work has been stopped for the present season. It is intended to begin again as early as possible in the spring of next year, and to follow the line taken by the fissure either along the easterly branch, or the one proceeding in a northerly direction; as may be most advantageous. From the results already obtained it may naturally be expected that equally important discoveries may be still in store to be brought out by next year's exploration. Your Committee have every confidence in appealing to those gentlemen who have already subscribed to renew their subscriptions, and to others who take an interest in the work of Cave Explorations to become subscribers for the ensuing year.

Appended is a list of those gentlemen who have subscribed during the present year.

Professor Miall desires to explain that the address on the Raygill Exploration issued in the last Report of the Yorkshire Geological Society was printed from shorthand notes, and that by an unfortunate oversight he had no opportunity of seeing the report before publication. Some errors and omissions are due to this circumstance.

December 1st, 1880.

THE FOLLOWING IS A LIST OF SUBSCRIBERS TO THE RAYGILL FUND.

	£	s.	d.
Marquis of Ripon	10	0	0
Walter Morrison, J.P.	10	0	0
Jno. Brigg, J.P., F.G.S.	5	0	0
J. R. Dakyns, of H.M. Geological Survey ...	5	0	0
J. W. Davis, F.S.A., &c.	5	0	0

Dr. J. Evans, F.R.S., &c.	...	...	3	0	0
J. Ray Eddy, ...	...	...	2	0	0
W. P. Sladen, F.G.S.	...	...	1	1	0
W. Cash, F.G.S.	...	...	1	1	0
J. T. Atkinson, F.G.S. ...	...	...	1	1	0
W. Cheetham, ...	...	...	1	1	0
Dr. T. Anderson ...	...	...	1	1	0
Jos. Jackson, ...	...	...	1	1	0
J. Whiteley Ward, J.P.	...	...	1	1	0
R. H. Tiddeman, of H.M. Geol. Survey		...	1	1	0
W. C. Ryder, ...	...	...	1	1	0
Dr. Hallilay	...	...	1	1	0
Geo. Knowles, ...	...	...	1	1	0
R. Reynolds, F.C.S. ...	...	...	1	1	0
R. Carter, C.E., F.G.S. ...	...	...	1	1	0
Thos. Shaw, D.L., J.P. ...	...	...	1	1	0
J. Bedford, ...	...	...	1	1	0
J. M. McLandesborough, C.E.	...	...	1	1	0
T. W. Embleton, C.E.	...	...	1	0	0
A. R. Binnie, F.G.S., C.E.	...	...	0	10	6
H. Müller, ...	...	...	0	10	0
J. S. Colefax, ...	...	...	0	5	0
A. G. Cameron, of H.M. Geol. Survey		...	0	5	0

THE PHOTOGRAPH

Issued with this year's proceedings illustrates the appearance of the fissure at the end of October. A comparison of this photograph with the one issued by the Society for the year 1875, which depicts the appearance of the opening to the fissure at that time, will serve to shew the extent of the excavation to this date.

SECRETARY'S REPORT.

It is with pleasure that we are able to state that the Society continues to advance in prosperity. Four general meetings—one in the East Riding, one in the North Riding, and two in the West Riding, have been held during the present year.

In January, the Society met at Halifax, when our esteemed President, the Marquis of Ripon, presided at the meeting. Since that time his Lordship has been called upon to exercise much higher functions, and to preside over a great nation as the Viceroy of India. An opportunity was taken, previous to our president's departure for India, to congratulate him on the appointment to so dignified a position, and to assure his Lordship of the continued good wishes of the Society.

In April the Society met at York. Many of the antiquities of the city were pointed out by Canon Raine, and Dr. Tempest Anderson, and some time was spent in the Museum, under the guidence of Dr. Purvis. The third meeting was held at Middlesbrough, in the early part of July, in the rooms of the Literary and Philosophicial Society. Mr. Belk, the president of the Society, occupied the chair and delivered an address. The Society is much indebted to the gentlemen named, and also to the Rev. Thos. Adams, of York, and to Dr. W. Y. Veitch, and to Mr. Ward, of Middlesbrough, for their kind and ready assistance. On the day following the meeting, the members present and several other gentlemen under the guidance of Mr. Barron, of H.M. Geological Survey, had a Geological excursion to Loftus and Saltburn. The present meeting is the annual meeting held at Leeds, with Dr. T. Clifford Allbutt, President of the Literary and Philosophical Society, in the chair.

The number of members still increases. Last year the number was 207, at the present there are 234 names registered; being a gain of 27 during the year.

The council recommend that Ed. Akroyd, Esq., who has been a member and a vice-president of the Society very many years, should be elected an honorary member of the Society, in accordance with Rule V.

It is with much regret that the death of two of our members has to be announced, Mr. J. M. Barbour of Halifax, and the Rev. J. Fish, Rector of Hutton Ambo.

Perhaps the most important step taken by the Society during the past year, has resulted from a decision of the council to investigate the contents of a cave or fissure at Raygill, in Lothersdale. The funds for this exploration have been subscribed independently and apart from those of the Society, and the work has now being going on since the early part of June last. A special report on this subject will be presented at this meeting, so that it will be unnecessary to enter into further details at present.

The visits of the Society to York and Middlesbrough have resulted in the acceptance of the office of Local Secretary by the Rev. Thos. Adams, and Dr. W. Y. Veitch, respectively. The following is a complete list of the gentlemen who occupy the position of Local Secretary, with the places which they represent.

Barnsley	Thos. Lister.
Bradford	Thos. Tate, F.G.S.
Bridlington	G. W. Lamplugh, F.G.S.
Brighouse	T. W. Helliwell.
Driffield	Rev. E. M, Cole, M.A., F.G.S., &c.
Halifax	W. Cash, F.G.S.
Huddersfield	Peace Sykes.
Leeds	J. E. Bedford.
Mexbro'	Rowland Gascoigne, F.G.S.
Middlesbrough	Dr. W. Y. Veitch
Ripon	Rev. J. S. Tute, M.A.
Selby	J. T. Atkinson, F.G.S.
Sowerby Bridge	J. Marshall.
Thirsk	Ed. Gregson.
York	Rev. Thos. Adams, M.A., F.G.S.

Our Society is in communication with the following learned Societies in this country and abroad. An interchange of proceed-

ings with those Societies is made annually, and the volumes received may be consulted by the members on application to Mr. Crowther, at the Museum, Park Row, Leeds.

List of Societies whose Proceedings are forwarded to the Yorkshire Geological and Polytechnic Society :—

Yorkshire Archæological and Topographical Society.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania.
Royal Dublin Society.
Royal Historical and Archæological Association of Ireland.
Geologists' Association.
Manchester Geological Society.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
United States Geological Survey of the Territories.
Boston Society of Natural History.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway.
Sociètè-Geologique du Nord.
Oversigt over det Kongelige Danske Videnskabernes Selskabs, Kjopenhavn.
Museum of Comparative Zoology, Cambridge, U.S.A.
Watford Natural History Society and Hertfordshire Field Club.

Copies of the Proceedings of the Society for the following years may be had on application to Mr. Crowther, the Assistant Secretary, at the Museum, Park Row, Leeds, price 2s. 6d. each:—1840, 1841, 1842, 1843, 1844-5, 1845-6, 1847, 1848, 1851, 1853, 1854-5, 1858-9, 1860, 1862, 1864-5, 1865-6 1867, 1868, 1869, 1870, 1871, 1875, 1876, 1877, 1878, 1879.

MINUTES AND BALANCE SHEET.

Meeting of the Council at the Philosophical Hall, Leeds, December 10th, 1879.

Present—Rev. E. M. Cole, Prof. Miall, Messrs. Davis, Atkinson, and Gascoigne. Rev. E. Maule Cole, M.A., in the chair.

The Hon. Secretary read the minutes of the last meeting, which were confirmed.

Moved by Mr. Atkinson, seconded by Mr. Gascoigne, and carried—"That the next meeting be held at Halifax, on January 14th, 1880, and that Papers be read by Prof. Miall, Messrs. Sladen, Gascoigne, Wilson, Lamplugh, and Davis."

Moved by the Hon. Secretary, seconded by Mr. Atkinson, and carried—"That a special circular be printed to intimate to the members that a composition fee of £6 6s. constitutes a life-membership."

Moved by Mr. Gascoigne, seconded by the Rev. E. Maule Cole, and carried—"That it is desirable that steps should be taken to secure a thorough investigation of the Raygill Fissure and its contents, and that Profs. Green and Miall, and Messrs. Brigg and Davis, with power to add to their number, be appointed a Committee to carry out the Exploration."

Moved by the Rev. E. Maule Cole, seconded by Mr. Gascoigne, and carried—"That the Committee be empowered to collect subscriptions, make necessary arrangements for carrying on the work, and that the specimens collected shall be deposited in the Museum of the Literary and Philosophical Society at Leeds, pending the decision of the Council as to their final destination."

Meeting of the Society at the Hall of the Literary and Philosophical Society, Halifax, Wednesday, January 14th, 1880.

The Marquis of Ripon, K.G., (President) in the chair.

The Hon. Secretary read the minutes of last meeting, held at Skipton, which were confirmed.

The President delivered an Address "On the Work of Scientific Societies."

Moved by Mr. R. Gascoigne, seconded by the Hon. Secretary, and carried—"That Mr. Kirkby, of Mexboro', be a member of this Society."

Moved by the Hon. Secretary, seconded by Mr. Sladen, and carried—"That the Rev. Thos. Adams, M.A., of York, be a member of this Society.

Moved by Mr. Cash, seconded by Mr. F. Bowman, and carried—"That Messrs. Chas. Lister & Walter Townend, Halifax, and Mr. S. Hawking, Bradford, be members of this Society."

The following Papers were read:—

By Prof. L. C. Miall, F.G.S., "Notes on the Osteology of Ctenodus."

By W. P. Sladen, Esq., F.L.S., F.G.S., "On Traces of Ancestral relations in the structure of Asteroidea."

By Rowland Gascoigne, Esq., F.G.S., "On the Junction of the Permian and Coal Measures at Conisboro'."

By Ed. Wilson, Esq., F.G.S., "On the Age of the Pennine Chain."

By G. W. Lamplugh, Esq., F.G.S., "On the Existence of a Fault in the Chalk of Flamborough Head, with notes on the Drift of the Locality."

By J. W. Davis, Esq., F.L.S., F.G.S., "On the Distribution of the Fossil-fishes of the Yorkshire Coal-field.

On the motion of Mr. F. H. Bowman, seconded by Dr. Alexander, and supported by Mr. Davis—A vote of thanks was passed to the Chairman for presiding and for his address.

Moved by Mr. T. Shaw, seconded by Mr. W. Rowley, and carried—"That the best thanks be given to the Authors of Papers."

The members afterwards dined at the White Swan Hotel, Thomas Shaw, Esq., J.P., Deputy Lieutenant of the West-Riding, presiding.

Meeting of the Council at the Philosophical Hall, Leeds, April 28th, 1880.

Present—Messrs. Carter, Davis, Profs. Miall, Green, and Messrs. Tate, Embleton, and Lister. Mr. R. Carter, C.E., in the chair.

The Hon. Secretary read the minutes of the last meeting, which were confirmed.

Moved by Mr. T. W. Embleton, seconded by Mr. T. Tate, and carried—"That the next meeting of the Society be held at York, in May."

Moved by the Hon. Secretary, seconded by Prof. Miall, and carried—"That the following accounts be paid:—E. Wormald, Photographs, £25 17s. 6d.; Messrs. McCorquodale, Printing, £3 7s. 9d.

Meeting of the Society at York, May 19th, 1880.

The members were met at the Railway Station by several gentlemen resident in York, and Dr. Tempest Anderson conducted the party to Clifford's Tower, pointing out numerous objects of antiquarian interest on the way, especially noting a Roman Burial Ground, Micklegate Bar, and various matters connected with the walls, and still older mounds. After an inspection of Clifford's Tower, the party proceeded to the Guildhall and the Minister, and thence to the exhibition in connection with the Yorkshire Fine Art Society, where they were met by Mr. W. W. Hargrove, and Mr. E. Taylor, and conducted through the picture galleries.

The Museum of the Yorkshire Philosophical Society was next visited. The Geological Collections were shewn by Dr. Purvis, Curator. The Reed collection, recently presented to the Society, has rendered necessary an entire rearrangement, and this is now progressing rapidly under the care of Dr. Purvis; the result of his praiseworthy efforts elicited the admiration of the Society.

The Rev. Canon Raine next took charge of the party, and conducted it through St. Leonard's Hospital, St. Mary's Abbey, the Multangular Tower, and the Hospituim, explaining the different styles and periods of architecture; he also conducted the members through the Archeological Museum.

The meeting was afterwards held in the Lecture Theatre of the Yorkshire Philosophical Society.

On the motion of the Hon. Secretary, the Rev. Canon Raine took the chair.

The Hon. Secretary read the minutes of the last meeting, held at Halifax, which were confirmed.

Moved by Mr. J. E. Bedford, seconded by Mr. J. Hallilay, and carried—"That the following gentlemen be elected members of this Society:—Dr. Dunhill, York; Messrs. G. Bingley, Headingley; G. B Cole, Bradford; Robert S.

Kirk, Headingley; W. H. Wood, Leeds; W. H. Wood, Halifax; H. Child, Whitkirk; T. Gough, B.Sc., York; G. F. Tetley, Leeds; J. P. Ogden, Leeds; J. Booth, Ovenden; C. Hewson, Leeds; C. Forbes Sharp, Driffield; and the Rev. T. Bayley, Vicar of Weaverthorpe."

Moved by the Hon. Secretary, seconded by Mr. Barber, and carried—"That the best thanks of the Society be given to Dr. Tempest Anderson, Dr. Purvis, and Mr. W. Hargrove, for their presence and guidance that day."

On the motion of Mr. Arnold Lupton, a cordial vote of thanks was given to the Rev. Canon Raine for presiding and his kind attention during the day.

The members afterwards dined at the Station Hotel.

Meeting of the Society in the Hall of the Cleveland Literary and Philosophical Society, Middlesborough, on July 14th, 1880, and at Saltburn, on July 15th, 1880.

J. T. Belk, (President of the Cleveland Literary and Philosophical Society), in the chair.

The Hon. Secretary read the minutes of the last meeting, held at York, which were confirmed.

The Chairman delivered an address on the "The History of the Cleveland District."

Moved by Mr. W. Scott, seconded by Mr. J. E. Bedford, and carried—"That the following gentlemen be elected members of the Society:—Messrs. Belk, J. Stephenson, W. Dixon, J. T. Ward, Drs. Veitch and Hedley, Middlesborough, Messrs. T. Allison, Guisboro', W. Wilcock, Idle, and P. F. Lee, Bradford.

The following Papers were read:—

By W. Y. Veitch, Esq., M.D., "On the Geology of the Cleveland Coast, with notes on the Flora."

By Thos. Allison, Esq., "Notes on the Geology and Physical Geography of the Cleveland District."

By J. R. Dakyns, Esq., M.A., H.M. Geol. Survey, "On the Glacial Deposits north of Bridlington."

In the absence of Mr. Dakyns, the Hon. Secretary read the latter Paper.

A discussion took place on Mr. Allison's Paper, in which the Chairman, the Hon. Secretary, and Dr. Veitch took part.

Moved by the Chairman, seconded by Mr. W. D. Ramsey, Hartlepool, and carried—"That a vote of thanks be given to readers of Papers."

Moved by Mr. Davis, seconded by Mr. J. P. Ogden, and carried—"That a vote of thanks be given to the gentlemen who had so kindly placed the Lecture Hall of the Cleveland Institute at the disposal of the Society for their Meeting."

Moved by Mr. Davis, seconded by Mr. T. Allison, and carried —"That a cordial vote of thanks be given to the Chairman and to Mr. Ward, for their assistance in making the arrangements for this Meeting."

The members afterwards dined together at the Queen's Hotel, Dr. Veitch in the chair. Afterwards, the members visited the Blast Furnaces of Messrs. Samuelson, under the guidance of Mr. J. T. Ward.

On Thursday, the 15th, the members, accompanied by several members of the Tee's Valley Field Club and Mr Barron of H.M. Geol. Survey, left Middlesborough by train for Loftus. After inspecting and collecting fossils from a bed of Inferior Oolite near Loftus, the party proceeded to the coast, and the Geological features of the magnificent sections exposed between Rockcliffe and Saltburn in the Lower Lias were pointed out and explained by Mr. Barron. The members returned from Saltburn to their respective destinations the same evening.

Meeting of the Council at the Philosophical Hall, Leeds, August 11th, 1880.

Present—Messrs. Carter, Davis, Ward, and Bedford. R. Carter, Esq., in the chair.

The Hon. Secretary read the minutes of the last meeting, which were confirmed.

The Hon. Secretary reported that a meeting had been held at Middlesborough on the 14th and 15th of July, at which J. T. Belk, Esq., presided; and that Papers were read by Dr. Veitch, J. R. Dakyns, M.A., and T. Allison.

Moved by Mr. Sykes Ward, seconded by Mr. J. E. Bedford, and carried—"That the following accounts be paid:— W. Burnett, £1 17s. 6d, Midland and Cleveland News, 3s. 6d., Courier, 4s., Guardian, 4s.

Moved by Mr. Bedford, seconded by Mr. Ward, and carried —"That the subject of the Photograph for next year be left with the Hon. Secretary."

Moved by the Hon. Secretary, seconded by Mr. Carter, and carried—"That the Annual Meeting be held at Leeds, and that it take place in October."

Annual Meeting, held in the Philosophical Hall, Leeds, September 29th, 1880.

The chair was occupied by T. Clifford Allbutt, Esq., M.A., M.D., F.R.S., &c., President of the Leeds Philosophical and Literary Society.

The Hon. Secretary read the Annual Report.

The Treasurer presented a Balance Sheet. On the motion of Mr. R. Carter, seconded by Mr. T. W. Embleton, the Report and Balance Sheet were adopted.

The Hon. Secretary read a Report "On the Raygill Fissure Exploration."

Prof. Miall presented an *ad interium* Report "On the Remains of Mammalia found in the Fissure."

Moved by the Hon. Secretary, seconded by the Rev. Thomas Adams, and carried—"That Dr. T. C. Allbutt, M.A., F.R.S., Messrs. Benj. C. Cross, C.E., and T. H. Gray, be elected members of the Society."

Moved by Mr. T. W. Embleton, seconded by Mr. W. Rowley, and carried—"That the Marquis of Ripon, K.G., be re-elected President."

Moved by Mr. John Brigg, seconded by Mr. Benj. Holgate, and carried—"That the Vice-Presidents be re-elected, with the addition of Dr. T. C. Allbutt, F.R.S."

Moved by Mr. W. Cheetham, seconded by Mr. R. Reynolds, and carried—"That Mr. John Brigg, J.P., be re-elected Treasurer."

Moved by the Rev. Thomas Adams, M.A., seconded by Mr. J. E. Bedford, and carried—"That Mr. J. W. Davis, F.G.S., be re-elected Honorary Secretary."

Moved by Mr. A. Lupton, seconded by the Hon. Secretary, and carried—"That the following gentleman be elected members of the Council:—Wm Alexander, M.D, J.P.; R. Carter, C.E., F.G.S.; T. W. Embleton, C.E.; E.

Filliter, C.E., F.G.S.; Prof. A. H. Green, M.A., F.G.S.; H. P. Holt, C.E., F.G.S.; Prof. L. C. Miall, F.G.S.; R. Reynolds, F.G.S.; W. Rowley; W. P. Sladen, F.L.S., F.G.S.; H. C, Sorby, LL.D., F.R.S.; and W. Sykes Ward, F.G.S."

Moved by the Hon. Secretary, seconded by Mr. R. Carter, and carried—"That a vote of thanks be accorded to P. W. Spencer, Esq., and to Mr. Todd, for their kind and generous assistance in connection with the Exploration of the Raygill Fissure."

The Chairman delivered an address.

The following Papers were read:—

By the Rev. J. Magens Mello, M.A., F.G.S., "On the Results of the Creswell Cave Exploration."

A discussion followed in which Prof. Miall, Messrs. J. Brigg, J. W. Davis, and R. Carter, took part.

By W. H. Wood, Esq., F.G.S., "On a Chemical method for distinguishing Black Obsidian from Black Blast Furnace Slag."

By Benj. Holgate, Esq., F.G.S., "On a Section in the Coal Measures at Leeds."

By J. W. Davis, Esq., F.G.S., "On a Group of Erratic Boulders at Norber, near Clapham, in Yorkshire."

Having another engagement, Dr. Allbutt requested R. Carter, Esq., to take the chair.

A vote of thanks to the Authors of Papers was proposed by the Chairman, and was carried unanimously.

Moved by Mr. Cheetham, seconded by the Rev. Thos. Adams, M.A., and carried—"That a vote of thanks be given to the Chairman."

The members afterwards dined together at the Queen's Hotel.

Council Meeting held October 13th, 1880.

Present W. Sykes Ward, Profs. Miall and Green, and T. W. Embleton. Mr. W. Sykes Ward, in the chair.

The Assistant Secretary read the minutes of the last meeting, which were confirmed.

Moved by Prof. Miall, seconded by Prof. Green, and carried —"That A. Megson's tender be accepted for the letterpress."

Moved by Prof. Green, seconded by T. W. Embleton, and carried—"That the Hon. Secretary be empowered to call together the next General Meeting of the Society without a Preliminary Meeting of the Council."

PRESIDENT:

The Most Hon. the Marquis of Ripon, K.G., F.R.S., &c.

VICE-PRESIDENTS:

His Grace The Duke of Leeds.
His Grace the Duke of Norfolk.
The Right Hon. Earl Fitzwilliam.
The Right Hon. Earl of Effingham.
The Right Hon. Earl of Wharncliffe.
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TREASURER:

John Brigg, J.P., F.G.S.

HON. SECRETARY:

J. W. Davis, F.S.A., F.G.S., &c.

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Wm. Alexander, M.D., J.P.	H. P. Holt, C.E., F.G.S.
Walter Rowley.	Prof. L. C. Miall, F.G.S.
R. Carter, C.E., F.G.S.	R. Reynolds, F.C.S.
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Prof. A. H. Green, M.A., F.G.S.	W. Sykes Ward, F.C.S.

Statement of Receipts and Expenditure of the Yorkshire Geological and Polytechnic Society,

Dr. FROM OCTOBER 1st, 1879, TO SEPTEMBER, 30th, 1880. **Cr.**

	£	s.	d.		£	s.	d.
To Balance	3	11	6½	By Cash paid into the Bank	84	5	7
„ Subscriptions, 1879	114	12	0	„ Stationery	42	12	6
„ Beckett & Co.	76	4	3	„ Advertising	2	19	0
				„ Postage and Carriage	11	2	3
				„ Cost of Photographs	25	17	6
				„ Expenses	10	0	11
				„ Salary of Assistant-Secretary, to May 31st, 1880, (12 months)	15	0	0
				„ Balance in Hand	2	10	0½
	£194	7	9½		£194	7	9½

Dr. *The Treasurer in Account with Beckett & Co.* **Cr.**

	£	s.	d.		£	s.	d.
To Balance at Bank	24	16	7	By Cash from Bank	76	4	3
„ Cash paid to Bank	84	5	7	„ Balance in Bank	33	11	11
„ Interest	0	14	0				
	£109	16	2		£109	16	2

Dr. *The Treasurer in Account with Beckett & Co.* **Cr.**

CAPITAL ACCOUNT.

	£	s.	d.
To Cash Paid into the Bank	88	4	0
„ Interest	0	1	3
	£88	5	3

Examined and found Correct, B. HOLGATE.

Summary of Geological Literature relating to Yorkshire, published during 1878, 1879 and 1880

Compiled by James W. Davis.

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——— On the Occurence of certain Fish Remains in the Coal-measures, and the Evidence they afford of their Fresh Water Origin. *Rep. Brit. Assoc. for* 1878, sections, p. 539.

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——— Description of a New Species of Fossil Fish Spine *(Ctenacanthus minor)* from the Lower Coal-measures of Yorkshire. *Geol. Mag.* dec. ii., vol. vi., p. 531.

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LAMPLUGH, G. W. On the Occurrence of Freshwater Remains in the Boulder Clay at Bridlington. *Geol. Mag.*, dec. ii., vol. vi., p. 393.

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LYCETT, J. A Monograph of the British Fossil Trigoniæ, no. 5. *Palæont. Soc.*, vol. xxxiii. ? Yorkshire.

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PARSONS, DR. H. F. The Trias of the Southern Part of the Vale of York. *Proc. Yorks. Geol. Soc.*, vol. vii., p. 154, pl. xi. xii.

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TATE, THOMAS. The Source of the River Aire. *Proc. Yorks. Geol. Soc.*, vol. vii., p. 177.

——— Note on an Intermittent Spring at Malham. *Ibid.* p. 186.

TUTE, J. S. On an Orthoceras of the Millstone Grit. *Proc. Yorks. Geol. Soc*, vol. vii., p. 82.

WRIGHT, DR. T. Monograph on the Lias Ammonites of the British Islands. Part 2. *Palæont. Soc.*, vol. xxxiii.

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CLOUGH, C. T. The Whin Sill of Teesdale, as an assimilator of the surrounding beds. *Geol. Mag.*, dec. ii., vol. vii., p. 433.

AVIDSON, DR. T. A Monograph of the British Fossil Brachiopoda. Vol. iv., pt. 3. *Palæont. Soc.*, vol. xxxiv.

DAVIS, J. W. On the Fish-remains found in the Cannel Coal, in the Middle Coal-measures of the West Riding of Yorkshire, with the descriptions of some new species. *Quar. Journ. Geol. Soc.*, vol. xxxvi., p. 56. (*Compsacanthus triangularis*, *C. major*, *Ostracacanthus* (n. gen.) *dilatatus*, novæ species).

——— On the Genus *Pleuracanthus*, Agass., including the Genera *Orthacanthus*, Agass., *Diplodus*, Agass., and *Xenacanthus*, Beyr. *Ibid.* p. 321, pl. xii. (*P. erectus*, *tenuis*, *pulchellus*, *alternidentatus*, *alatus*, *robustus*, *Wardi*, *denticulatus*, novæ species.

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——— On the Teleostean affinities of the genus Pleuracanthus. (Ref. to Yorkshire Specimins.) *Ann. and Mag. of Nat. History*, 5th series, vol. v., p. 349.

——— On a new species of Gyracanthus, a Fossil Fish from the Coal-measures. *Ibid.* vol. vi., p. 372.

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*** The compiler has much pleasure in acknowledging the kind assistance received from the Editors of the *Geological Record*, who have placed their advanced Sheets and MS. at his disposal. Thanks are especially due to W. H. Dalton, Esq., of H.M. Geological Survey.

ERRATA IN LISTS PUBLISHED IN THE PROCEEDINGS, VOL. VII.

Page 98, line 1, *for* Greenfell *read* Grenfell.
„ „ 4, add *Rep. Brit. Assoc.* for 1875, *Sections* p. 85.
„ Horizontal Sects., in each, *read C.* Fox Strangways.
„ And in sheet 98, for "Measure *read* Measures."
„ *Dele* to "Permian Limestone," and *after* Cliff *add* and.
„ *Dele* Penning.
„ To Thorpe *add* ser., vol. and p. before the numerals.
Page 99, line 2, for North West, read N.W. (Barnsley)
„ In Green *for* "An Exceptional Occurrence," *read* a Section.
„ *For* Rance, C. E., De, *read* De Rance, C. E., and transfer to place accordingly.
„ Tiddeman, *5th Rep.* is 1878, and *for* should be inserted after *Assoc.*
Page 212, Hull number 2, for Sarles, read Sarle, *with the addition*, [rightly Collingham, Notts.]
„ For South West, *read* S.W., (Rotherham.)

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*** It is requested that Members changing their residence will communicate with the Secretary.

METEOROLOGY OF BRADFORD FOR 1880.

Computed from daily observations made at the Exchange, Bradford, by J. McLandsborough, M. Inst. C.E., F.R.A.S., F.G.S.
Latitude, 53 deg. 47 min. 38 sec. N.; longitude, 1 deg. 45 min. 4 sec. W.; height above mean sea level, 366 feet.

Months	Pressure of Atmosphere in Month: Highest Reading of Barometer	Lowest Reading of Barometer	Range	Corrected for Capillarity and Temperature: Mean	Mean of 12 Years	Temperature of Air in Month: Highest	Lowest	Range	Mean of all Highest	Mean of all Lowest	Mean Daily Range: Mean	Mean of 12 years	Of Dry Bulb
	Ins	Ins	Ins	Ins	Ins	Deg	Deg	Deg	Deg	Deg	Deg	Deg	Deg
January	30·332	29·360	0·972	29·918	29·511	54·3	20·8	33·5	40·6	32·2	8·4	8·9	37·2
February	30·012	28·588	1·424	29·298	29·475	52·8	28·0	24·8	47·4	37·1	9·5	9·1	42·7
March	30·206	28·672	1·534	29·648	29·505	55·1	32·9	22·2	48·5	37·1	11·4	11·5	41·5
April	30·148	[illegible]	1·302	29·440	29·478	60·3	32·0	28·3	52·6	40·4	12·2	13·0	45·3
May	30·094	29·324	0·770	29·670	29·561	67·0	34·6	32·4	58·1	43·1	15·0	14·4	48·0
June	29·992	29·184	0·808	29·513	29·537	71·4	39·0	32·4	63·2	50·1	13·1	15·2	54·2
July	29·822	29·168	0·654	29·436	29·527	71·0	49·7	21·3	65·3	53·9	11·4	15·4	57·8
August	30·010	29·188	0·822	29·643	29·513	79·3	49·5	29·8	69·3	55·5	13·8	14·6	60·7
September	30·156	28·956	1·200	29·552	29·494	81·3	45·0	36·3	66·3	53·3	13·0	12·[illegible]	58·1
October	30·049	29·000	1·042	29·516	29·433	62·1	26·7	25·4	56·3	[illegible]	11·1	11·6	44·5
November	30·060	28·154	1·906	29·442	29·444	57·4	23·0	34·4	47·0	36·6	10·4	9·2	41·0
December	30·234	28·720	1·514	29·436	29·466	54·0	26·2	27·8	45·2	36·5	8·7	8·5	41·2
Means, or totals	30·092	28·930	1·162	29·542	29·495	63·0	34·0	29·9	54·5	43·0	11·5	12·0	47·7
Means of 12 years	30·058	28·904	1·154	29·495	29·495	65·0	33·5	31·5	54·8	42·7	12·0	12·0	48·1

Months	Adopted Mean Temperature: Of Air: Mean	Mean of 12 years	Of Evaporation	Dew Point	Vapour: Elastic Force	In a Cubic Foot of Air: Mean	Short of Saturation	Degree of Humidity (Complete Saturation = 100): Highest	Lowest	Mean	Mean of 12 years	Mean Weight of a Cubic Foot of Air	Highest Reading of Maximum Thermometer in Rays of Sun	Mean Reading of Maximum Thermometer in Rays of Sun
	Deg	Deg	Deg	Deg	Ins	Grs	Grs	0–100	0–100	0–100	0–100	Grs	Deg	Deg
January	36·7	39·1	34·7	31·8	·171	2·1	0·5	93	61	83	86	559	64·6	42·[illegible]
February	42·5	39·9	40·5	38·1	·230	2·[illegible]	0·5	[illegible]	58	85	86	5[illegible]	70·2	52·1
March	41·7	40·7	39·6	37·0	·221	2·5	0·5	97	65	85	83	54[illegible]	80·0	66·7
April	45·2	45·7	41·[illegible]	37·9	·2[illegible]	2·6	0·8	91	61	76	77	5[illegible]	99·2	72·5
May	48·6	49·[illegible]	44·9	40·7	·255	2·1	1·1	97	51	73	75	541	96·6	[illegible]
June	54·5	55·9	51·1	47·8	·331	3·8	1·0	92	53	78	72	531	97·4	80·4
July	57·8	60·8	54·3	51·2	·377	4·2	1·1	94	51	79	69	526	99·0	83·5
August	60·7	59·4	56·3	52·5	·395	4·4	1·5	89	59	74	74	527	112·0	82·4
September	58·3	55·0	54·9	51·8	[illegible]	4·3	1·1	91	60	7[illegible]	78	5[illegible]	1[illegible]1·3	76·6
October	44·1	48·3	41·5	38·4	·233	2·7	0·6	95	[illegible]	86	[illegible]	543	75·7	[illegible]
November	41·2	41·[illegible]	[illegible]	35·5	·210	2·4	0·6	[illegible]	[illegible]	[illegible]	[illegible]	5[illegible]	[illegible]	54·0
December	41·0	38·3	[illegible]	36·3	·213	2·5	0·5	[illegible]	70	[illegible]	84	545	59·0	[illegible]
Means, or totals	47·7	47·[illegible]	44·8	41·6	·272	3·1	0·8	95	59	80	79	539	85·1	66·6
Means of 12 years	47·8	47·8	44·7	41·3	·268	3·1	0·9	94	60	79	79	538	92·2	70·8

Months	Wind: Highest Estimated Strength	Mean Estimated Strength	Relative Proportion of at 9 a.m.: N	NE	E	SE	S	SW	W	NW	Perfectly Calm	Mean Amount of Cloud	Rain: Number of Days it fell	Amount Collected	Mean of Twelve Years	Greatest Daily Fall	Date
	0–6	0–6	No	No	No	No	No	No	No	No	No	0–10	No	Ins	Ins	Ins	On
January	2·0	1·1	0	7	0	9	1	6	[illegible]	5	0	6·2	9	[illegible]	2·51	[illegible]	1st
February	3·5	1·6	0	2	2	2	1	10	9	3	0	7·2	21	2·56	1·86	0·65	17th
March	2·5	1·2	1	3	4	11	1	4	6	1	0	6·6	15	2·76	2·01	[illegible]	3rd
April	2·5	1·5	0	11	1	1	1	12	2	2	0	6·5	22	[illegible]	[illegible]	[illegible]	[illegible]
May	2·5	1·[illegible]	0	12	3	0	0	[illegible]	[illegible]	5	[illegible]	6·5	14	[illegible]	2·01	[illegible]	26th
June	2·5	1·0	0	8	1	10	1	2	4	4	0	7·0	23	1·92	2·42	0·31	20th
July	2·0	1·0	0	4	1	7	0	7	10	2	0	7·3	26	5·89	2·63	0·94	13th
August	1·6	0·6	0	12	4	[illegible]	4	1	4	[illegible]	[illegible]	6·5	13	[illegible]	[illegible]	[illegible]	7th
September	1·5	0·8	[illegible]	[illegible]	1	3	3	5	[illegible]	6	0	5·8	16	[illegible]	[illegible]	0·96	12th
October	3·0	1·0	2	15	5	1	0	5	0	3	0	7·[illegible]	[illegible]	4·67	3·4[illegible]	1·71	24th
November	2·[illegible]	[illegible]	2	3	1	2	1	8	7	6	0	6·0	[illegible]	3·08	2·[illegible]	0·67	13th
December	2·5	0·9	2	1	[illegible]	5	1	6	7	6	0	7·5	24	4·16	2·7[illegible]	1·06	22nd
Means, or totals	2·3	1·1	7	84	26	54	14	74	61	46	0	6·7	223	35·69	2·52	0·96	
Means of 12 years	3·0	1·1	34	52	30	31	26	60	78	51	3	6·6	178	30·22	30·22	0·69	

Yearly Maximum and Minimum Atmospheric Pressure, Temperature, Humidity, and Rainfall, from 1869 to 1880 inclusive.

EXPLANATION.

The observations are made at nine a.m., and, with the exception of maximum and minimum thermometer readings, again at three p.m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for capillarity, temperature, and diurnal range. To correct for altitude or reduce to sea level, the air temperature being 43 degrees and barometer reading 30 inches at sea level, add ·401 inches to the heights given.

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings; the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c., are deduced from bi-daily readings of the dry and wet bulb hygrometer.

Year	Pressure: Highest: Reading of Barometer during Year	Date	Lowest: Reading of Barometer during Year	Date	Temperature: In Shade: Highest: Reading of Maximum Thermometer during Year	Date	Lowest: Reading of Minimum Thermometer during Year	Date	In Sun's Rays: Highest: Reading of Solar Thermometer during Year	Date	Humidity (Complete Saturation = 100): Highest: Degree of Humidity during Year	Date	Lowest: Degree of Humidity during Year	Date	Rain: Total for Year	Greatest Daily Fall during Year	Date
	Ins		Ins		Deg		Deg		Deg		0–100		0–100		Ins	Ins	
1869	30·200	Dec 6	28·500	Feb 1	85·2	Aug 20	14·8	Dec 28	127·7	Aug 30	[illegible]	Feb 4	42	Sep 24	21·[illegible]	0·570	Dec 13
1870	30·284	Jan 19	28·[illegible]	Jan 8	85·0	July 25	16·6	Dec 23	127·5	July 25	98	Jan 29	40	May 14	21·1[illegible]	0·[illegible]20	June 1
1871	30·152	Mar 29	28·208	Jan 16	84·0	Aug 12	6·7	Jan 1	1[illegible]·7	July 17	[illegible]	July 7	43	Nov 2	21·[illegible]40	0·[illegible]	June 16
1872	30·156	April 6	28·670	Jan 24	8[illegible]·4	July 23	24·8	Mar 27	1[illegible]4·3	Aug 19	100	Mar 22	45	Sep 23	42·[illegible]	2·400	June 10
1873	30·338	Feb 18	28·[illegible]22	Jan 20	8[illegible]·8	July 23	19·2	Feb 24	1[illegible]4·5	July 23	100	Dec 11	41	Mar 26	[illegible]	[illegible]	Aug 4
1874	30·476	Mar 6	28·276	Dec 11	80·9	July 20	1[illegible]·0	Feb [illegible]	125·8	July 20	100	Feb 6	42	May 18	2[illegible]	0·710	Dec 7
1875	30·405	July 7	28·484	Nov 10	89·0	Aug 17	1[illegible]·0	Jan 1	122·0	July 5	[illegible]	Jan 2[illegible]	4[illegible]	[illegible]	[illegible]	1·7[illegible]	Nov 15
1876	30·300	Jan 15	28·070	Dec 4	87·6	July 17	23·0	Jan [illegible]	125·6	July 16	[illegible]	Oct 4	46	May 6	[illegible]	1·[illegible]	Oct [illegible]
1877	30·358	Oct 6	28·300	Nov 29	[illegible]0·0	June 1[illegible]	2[illegible]·0	Mar 1	116·4	June 15	100	Oct 29	[illegible]	May 23	[illegible]	1·420	July 16
1878	30·520	Mar 16	28·630	April 1	83·6	July 19	1[illegible]·9	Dec 26	118·2	July 22	[illegible]	Jan 13	53	Aug 9	35·[illegible]34	1·2[illegible]	Aug 14
1879	30·352	Dec 13	28·500	Feb 10	74·4	July [illegible]	13·2	Dec 7	1[illegible]	Aug 13	100	Oct 7	51	Dec 12	[illegible]	1·[illegible]0	June 8
1880	30·332	Jan 7	28·154	Nov 16	81·3	Sep 5	20·8	Jan 20	11[illegible]·0	Aug. 13	99	Dec 15	50	May 30	35·[illegible]	1·710	Oct 27
Means	30·305		28·302		83·6		17·2		121·2		99		44		30·153	1·332	

The solar thermometer has a black bulb enclosed in a vacuum.

The force of wind is estimated by a scale ranging from 0 to 6, the square of the number of scale giving the pressure in pounds per square foot.

The amount of cloud is estimated by a scale ranging from 0 to 10. The rain gauge is 65 feet above the surface of ground, and therefore registers less than if on the surface. Gauges placed on the surface near the Town Hall and at the Midland Railway Station show the mean yearly rainfall at these places for the five years ending with 1880 to be 38·842 inches, while that at the Exchange for the same period amounts to 35·016 inches, or 3·826 inches less than on the surface.

All the instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

The mean of twelve years, where given, is for that period ending with 1880.

PROCEEDINGS

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EDITED BY JAMES W. DAVIS, F.S.A., F.L.S., F.G.S.

1881.

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THE PHOTOGRAPH.

The photograph issued with this volume of proceedings represents a large block of Silurian Rock perched upon Mountain Limestone. It is situated at Norber, near Clapham, in Yorkshire. A paper relating to the Erratic Blocks at Norber was printed in the proceedings for last year, page 266, which may be consulted for further particulars.

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EDITED BY JAMES W. DAVIS, F.S.A., F.L.S., F.G.S.

1881.

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GEOLOGICAL AND POLYTECHNIC SOCIETY.

EDITED BY JAMES W. DAVIS, F.S.A., F.G.S., &c.

1881.

NOTES ON THE CARBONIFEROUS POLYZOA OF NORTH YORKSHIRE. BY GEORGE ROBERT VINE.

SEVERAL years ago I received from Mr. John Harker, of Richmond, in Yorkshire, a small packet of Shale, marked "Richmond"; and a few organisms picked out, mounted on slips, and marked, "Hurst" and "Downholme." The organisms were unnamed, but they belonged to several Genera of Polyzoa, Entomostraca, and Foraminifera. After this, I had sent to me to be named about seventy-three slides, and several blocks of Limestone and Shells, on which were incrusting *Fenestella* and *Berenicea.* Many of the specimens mounted on the slips were duplicates, and as near as I can remember they were collected together from the neighbourhood of Richmond and Hurst. Mr. Harker was devoting his attention to the Entomostracia and Foraminifera of the Carboniferious series; and besides these, he very wisely mounted and preserved other organisms as well. Always in very delicate health, our correspondence was cut short by his death, and the exact localities of his specimens are thereby lost, for since his death his collection has been scattered abroad. I tried to purchase his slips of Polyzoa, but I never had an answer to my offer, and thus this

collection of a good local worker is now, I believe, not available for reference and identification. I have, however, the box of Shale; and since I have been asked to read a Paper on Polyzoa before the Members of this Society, I thought that no better opportunity than the present would be offered me in working out for you the Polyzoa of these Northern Limestone Shales.

There is not known in the whole of Great Britain Shales so rich in organic forms as the Hairmyres Shale of Scotland. Passing over other species there are no fewer than about twenty-four or twenty-six distinctly typical Polyzoa. The individuals are so numerous that their fragments may be reckoned by millions, and a pound or so of the unwashed Shale, will yield after washing, employment in mounting for many years. It was from this storehouse that the Messrs. Young, of Glasgow, gathered so many of their choicest treasures, and I may say that many species really new to science are not yet exhausted. These Shales belong to the lower Limestone series of Scotland, the equivalent of which would be the stage B. of Etheridge; or perhaps more plainly speaking, the equivalent of the "Scaur Limestone Series" of the North of England.* It is not so much the Geological horizon that I want to discuss now as the Palæontological. The Polyzoa of the Hairmyres district are beautifully preserved, and one genus at least, the *Glauconome*, is typical in all its species; and I venture to say that any one who has carefully examined the Hairmyres *Glauconome* could never afterwards be mistaken in their identity. The *Cerioporidæ* are also well represented; and the genera *Rhabdomeson*, *Ceriopora*, and *Hyphasmapora* do not differ from similar genera found in other localities. If we leave the lower Limestones series of Scotland, and examine the Polyzoa in some of the Shales of the upper Limestone series, a marked difference in the character of the species is immediately noticeable. In the Gare and Belstonburn districts it is sometimes

* Robert Etheridge, Esq., F.R.S., Presidential Address to the Geological Society, 1881, p. 177.

difficult to make out the typical characters of *Glauconome* found in the Shales. There are, however, marked *facies* in the species of this genus very easily recognizable even when many of the characters are absent. The *Fenestella*, and also the *Palæocoryne* of Duncan, are very well preserved. When species from either Gare or Belstonburn are compared with the species from the neighbourhood of Hurst and Richmond, there is a striking similarity between them; so much so, that some of the more characteristic specimens from any one of the localities are scarcely distinguishable. This is especially true of the *Fenestella polyporata*, and the *Palæocoryne radiatum*, Duncan. At one time I was disposed to favour the idea that the Polyzoa of the Yorkshire, and the Polyzoa of Belstonburn districts, were of the same horizon; and believing such to be the case, I wrote to Mr. John Young, of Glasgow, to that effect. In answer he wrote me :—"In your letter you say that the Polyzoa of the Richmond Limestone series resemble very much those from the Belstonburn Shale, Carluke. This latter Shale lies high in our upper Limestone series, not far from the millstone grit of our Scotch Coal Measures. It would be interesting to find what is the position of the Richmond series. Lately, I got some pieces of Shale sent me from Muirkirk, in Ayrshire, with fronds of *Fenestella* identical with those of the Belstonburn Shale. It also contains an undescribed Polyzoa found in both localities."*

This correspondence of specific type is not, however, complete. There is a difference in the abundance of species in the two places. In our Yorkshire Shales *Rhabdomeson rhombiferum* and *R. gracile* are very abundant. In the Belstonburn Shales these species are very rare. *Sulcoretepora parallela*, Phill., *and Goniocladia cellulifera* Etheridge. Jun., are about equally distributed; and there is a similarity between the *Polypora*; the *Glauconome elegans*, Young and Y., and *G. aspera*, Y.Y., present the same markedly crushed character; but in the Belstonburn district we

* Mr. John Young's Letter, dated May, 1878.

have three species wholly unrepresented in the Yorkshire Shales. 1. *Synocladia scotica*, Young. 2. *Glauconome robusta*, Young. 3. *Thamniscus Rankini*, Young. I cannot build much upon the other species, because the Shales are not of my own washing, and the coarser debris I have not received. For the purpose of this comparison I have examined about the same weight of material, and the colour of the Shale from both localities is of the same dark muddy character found in the Shales of many of the upper Limestone series of Scotland Since this examination was made I have had an opportunity of studying the Polyzoa of the Upper Limestone Shales of Gare. Here, also, there is a resemblance between species found in all three of the districts named above. I cannot help the conclusion, therefore, that the same seas which ebbed and flowed over that part of Scotland, now called Gare and Belstonburn, ebbed and flowed also over the Northern part of Yorkshire, Durham, and Northumberland. In the difference of specific types we may have some partial evidence of the depths of the seas, but in the absence of other fossils we cannot build much upon this.

It is pleasing to note the varied ranges of some few of the rarer species of Polyzoa. The *Hyphasmapora Buskii*, Eth. Jun., is rather plentiful in the lower Limestone Shales of Scotland, though compared with other species found in the same Shales it may be characterised as not frequent. I have several specimens from the lower Limestone Shales of Hairmyres,—it is found at High Blantyre and in the Shales of Brankemhall. I have detected fragments in the Welsh Shales. I have no record of the species in the upper Limestone Shales of Scotland, but I have fragments from the Northumberland Shales, Ridesdale, and also specimens from Hurst.

Rhabdomeson gracile has a very wide range. It was originally described by Phillips as occurring in the Pilton group of Devon; it is present in nearly all the Shales of the upper and lower Limestone series, including the Calciferous Sandstones of Scotland.

The range of *R. rhombiferum* I have not such a wide record of, but it is generally present in Shales where the other species is found.

The following table will show the range of other species described as found in North Yorkshire. I have prefered, however, to mark only those that are in my own cabinet.

GLAUCONOME, Goldfuss.

1826. Genus established by Goldfuss, but Munster described as Glanconome species of *Cellaria*.

1839. Genus revised by Lonsdale, Type of the Genus *Glauconome disticha*, Goldfuss. Stem, stony, thin, elongated oval, branched ; cells disposed longitudinally and alternately, in rows, over half the surface, the other half straited longitudinally."—Lonsdale, Silurian System, p. 676.

1. Glauconome *marginalis*. Young & Young, Diplopora *marginalis*. Sub-Genus, Y. & Y. Proceedings of Glasgow Nat. Hist. Soc., 1875, Plate iii., Fig. 14—21.

This is the most delicate species of the Genus, and the branching is very different from that of other species of Glauconome. There are no pinnules, and the branches strike off at wide intervals either laterally or as bifurcations. There is a mesial ridge between the marginal cells, and this bears a tubercle between each cell. There are also small cells below the larger one, and the thin marginal line which separates them is often broken away, thus giving to the cell a kind of pyriform structure.

Locality :—Very rare in the Shales of Hurst, Yorkshire.

2. Glauconome *stellipora*. Young & Young. Pl. xvi, Fig. 1. Acanthopora *stellipora*. Y. & Y., Sub-Genus. Pro. of Nat. Hist. Society, Glasgow, 1875. *G. stellipora*. Y. & Y. Quart. Journ. Geol. Soc., 1874, Pl. xi., Fig. 5-11.

This species is rather abundant in the Shales, and also in the Limestone. The stem has a less angular appearance than the typical species, owing to the crushed state in which they are sometimes found. The mesial ridge is more frequently straight than sinuous, but the fine beading of the ridges, and the other

ornamentations characteristic of the species, are well preserved. Sometimes the wall separating the large from the smaller pore is broken, giving to the cell a somewhat pyriform aspect; otherwise the typical eight rayed denticles are generally present in the specimens.

Localities:—Hurst, in Shales; Richmond, Limestone.

3. Glauconome *stellipora*. Var. *spinosa*. Young & Young. Pl. xvi, Fig. 2. Quart. Journ. Geol. Soc., 1874, Pl. xl., Fig. 9, 10, p. 682. Proceedings of Nat. Hist. Soc. of Glasgow, March, 1875.

Less abundant than the species, but the very prominent tuberculated keel is seen to perfection in some specimens; in others the keel and tubercles are rubbed off, and the mesial ridge appears to be flat and foraminated.

Locality:—Hurst, in Shales; Richmond, rare.

4. Glauconome *elegans*. Young & Young. Pl. xvi., Fig. 4. Proceedings Nat. Hist. Soc., Glasgow, March, 1875.

This beautiful species is rather rare in the upper Limestone series; it is well represented in the Shales of the lower series. There are, however, abundant evidence that the range was a wide one, and although in these Shales the specimens are flat and crushed, the typical character of the species can easily be detected.

Locality:—Hurst; Richmond.

5. Glauconome *aspera*. Young & Young. Pl. xvi., Fig. 3. Proceedings of Nat. Hist. Soc., Glasgow, 1875.

This very rare, but remarkable species, with its peculiarly ornamented peristome, is represented by a few small fragments. These, however, are very perfect and in one case the peristome is as perfect as the lower Limestone specimens of Hairmyres of Scotland. When the Messrs. Young gave their description of the species they said:—"We have only, as yet, obtained this species from the Shale of Hairmyres, where it is rare. It is found in the form of small branching fronds; rarely exceeding half

inch in length."* Another locality besides that of Hurst I have been able to add to the list.

Localities:—Hurst, Shale; Belstonburn, Hairmyres.

6. Glauconome *retroflexa*. Young & Young. Proceedings of Nat. Hist. Soc., Glasgow, March, 1875.

In their remarks on this species the Messrs. Young say:—"The backward flexure of short branches is the most distinctive character . . . .; the deeply burried appearance of the cells being second in importance."† Both these characters are shown in the Yorkshire specimens; but from their bulky appearance some of the specimens approach nearer to the *G. robusta*, Young & Young, of the upper Limestone series of Carluke. In giving the description of the latter species the authors say:—"From *G. retroflexa* it is distinguished by its stouter branches, the wider position of the tubercles on the keel, and the more numerous cells in proportion to the branchlets."‡ But for this last feature it would be hard to separate them.

Localities:—Hurst, Shales; Richmond, Limestone.

The *Fenestella* of the Shales are represented only by a few fragments, but these are very characteristic. The fragments of *F. nodulosa*, Phillips, of the type *Actinostoma*, Young & Young, and *F. polyporata*, Phillips, are identical with the Scotch species of the same type. The *F. plebeia*, McCoy, also corresponds with fragments found in the Scotch series; but the *F. tuberculo-carinata*, Eth., Jun., is wholly obscured by a peculiar coral growth. A very similar, or I might say, the same coral growth incrusted the same species of *Fenestella* in the district of Gare, Scotland, and I have not the least doubt that this incrustation is the *Hemitrypa* of authors, and in all probability is the *H. oculata* of Phillips. The *F. nodulosa* preserved in masses on the Limestone and shells, found in smaller fragments in the Shale, are remarkably fine; and the *Palæocoryne radiatum* and *scoticum*, of Duncan and

* I can bear witness to its rarity in these Shales.

† Proceedings, work cited, 1875.

‡ Proceeding Nat. Hist. Soc., Glasgow, 1877.

Jenkins, are often preserved in situ. One fragment of *Fenestella* that I have is a portion of a larger specimen that was in the possession of Mr. Harker. I have for the present allowed it to remain in the list as an undescribed form on account of the peculiarity of cell arrangement. I shall therefore record the following typical species as present in the Shales.

7. Fenestella *nodulosa*. Phill. Geol. of Yorkshire, pl. l., Fig. 31, 32, 33.
8. Fenestalla *plebeia*. McCoy. Syn. Carb. Foss., Ireland, pl. xxix, Fig. 3.
9. Fenestella *tuberculocarinata*. Eth., Jun. Mem, Geo. Surv., Scotland, sheet 23, p. 101.
10. Fenestella *polyporata*. Phill. Geol. of Yorkshire, pl. l., Fig. 19, 20.
11. Fenestella. Species undescribed.
12. Palceocoryne *radiatum*. Duncan & Jen. Phil. Trans., 1869, pl. lxvi.
13. Palceocoryne *scoticum*. Duncan & Jen. Phil. Trans., 1869, pl. lxvi.
14. Spiniferous processes of Young & Young. Quart. Journ. Geo. Soc., 1874.

The last three indistinguishable from Scotch specimens.

Localities:—Hurst, Shales; Richmond, Limestone.

15. Polypora *tuberculata* Prout Pl. xvi, Fig. v. Transactions of the Acad. Science, St. Louis (quoted by Y. & Y. below in a note on the occurrence of Polypora *tuberculata* Prout. Geo. Mag., June, 1874.)

In the above Paper the Messrs. Young, of Glasgow, give the description of Prout's species in full on account of the difficulty of obtaining the Transactions in this country. As the Messrs. Young are responsible for the identification, I can do no other than accept their work. The few Hurst specimens—for they are not numerous—very closely resemble the Scotch *Polypora* in many particulars. There are, however, two or three fragments which show the "slightly raised keel between the cells, and having . . .

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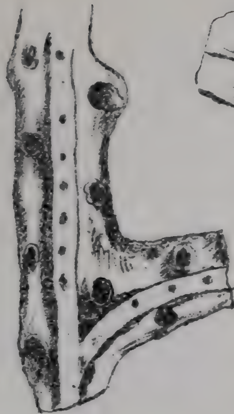
1.



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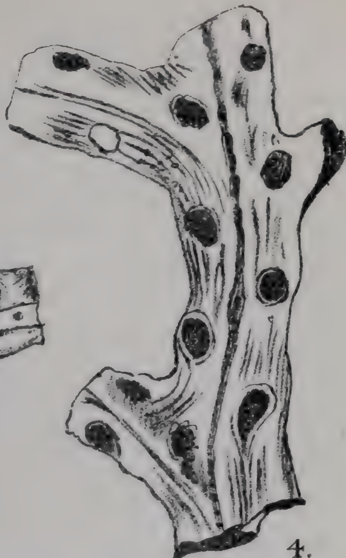

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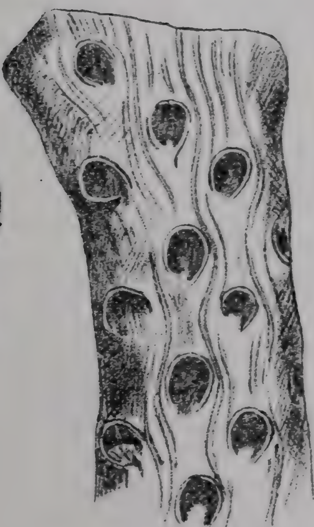

5.

6.

Hurst and Richmond Polyzoa.

on the middle keel an irregular line of round tubercles, which sometimes intermit and sometimes show a disposition to become double."* In the Scotch lower Limestone Shale beds of Hairmyres this species is very abundant; and after examining a large suit of specimens, and comparing the Yorkshire fragments with these, I cannot help placing them under the specific name which I have adopted. There is an additional interest in two fragments sent me by Mr. Harker, who was most careful in the location of his specimens. The two specimens are marked "Yoredale Rock, near Richmond." I can build nothing upon this statement, and I should have passed it over without reference had not the following occured in Mr. Etheridge's Address to the Geological Society. The Carboniferous Bryozoa, as a group, constitute by far the largest series in any division of the Palæozoic rocks. 77 species range through the three lower horizons of the Carboniferous series; . . . . . not a single species passes to or occurs in the *Yoredale*, Millstone Grit, or either one of the three divisions of the Coal Measures."† If such be a fact, and Mr. Harker's reference wrong, working Geologists in the Hurst or Richmond district can set the question at rest by working for fossils in these rocks.

Localities:—Hurst, Richmond, Limestone Shale; Yoredale, Rock (?)

16. Hyphasmapora *Buskii*, Etheridge, Jun. Pl. xvi, Fig. 6. Ann. Mag. Nat. Hist., ser. 4, vol. xv., p. 43-45, pl. iv., fig. 1-4.

Fragments of this beautiful species are present in the Shale, but are very rare. I have five fragments but so characteristic are they that there is no mistaking them, for the species is unique. In his Generic description, Mr. Etheridge says:—"Polyzoarium dendroid, calcareous, composed of small cylindrical stems, often bifurcating. Cell depressions arranged in linear, longitudinal series, more or less separated from one another by a

* These are typical features quoted from Prout, Geo. Mag., 1874.

† Presidential Address. Geo. Soc., p. 185, Feb., 1881.

cancellated network . . . . . The interstitial network consists of a series of irregularly formed pores. The only known species is named in honour of Prof. Busk."*

Locality:—Hurst. I have also found fragments in the Northumberland and Welsh Shales. It is rather abundant in the Lower Limestone Shales of Scotland.

17. Rhabdomeson *gracile.* Phillips. Palæozoic Fos. Devon, &c.
18. Rhabdomeson *rhombiferum.* Phillips. Geol. of Yorkshire. (*Millepora* species, Phillips; *Ceriopora,* Morris Catal). New Genus, Messrs. Young, *Rhabdomeson.* Ann. Mag. Nat. History, 1874, 1875.

These species are rather abundant in the Shales and Limestone, and very beautifully preserved. The tuberculous spines surrounding the cell mouths are remarkably prominent on some of the specimens; and the peristomial ridges of *R. rhombiferum* are well shown, but the specimens themselves are not so large as typical fragments from the Scotch beds.

Localities:—Hurst, Shales; Richmond, Limestone.

19. Ceriopora *similis.* Phillips. Palæozoic Fos. of Devon.

Good typical specimens of this species are very rare, but they are to be found in the Shales of Hurst. One specimen shows all the characters of the Scotch *C. similis.* I am unable to compare it with specimens from other localities.

20. Goniocladia *cellulifera.* Etheridge, Jun. Carinella *cellulifera.* Etheridge, Jun. Geo. Mag., October, 1873.
21. Sulcoretepora *parallela.* Phill. Flustra *parallela.* Phill. Geo. of Yorkshire.

Fragments of both these species are present in the Shales—the first rather more abundant than the other. It is almost impossible to detect any difference between the specimens of *Goniocladia* from Gare or Belstonburn, in Scotland, and those from Yorkshire. There is a slight difference in the *Sulcoretepora,* but of no specific importance.

Localities:—Hurst, Shales.

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* Annals as cited above, pp. 43-45.

22. Ceramopora *Megastoma.* M. Coy. (Berenicea sp.) Vine Review of Fam. *Diastoporidæ.* Quart. Journ. Geo. Soc., 1880.

This species is present in very large patches on Limestone, incrusting stems of Crinoids, and on Shells.

Localities:—Hurst, Shales; Richmond.

In addition to the above, I have one slide on which are fragments of *Rhabdomeson*, and attached are what I consider to be *Oœcia* of the species. I regard the discovery of these in so many localites of so much importance as to merit a separate study. In these beds I have only found specimens on the sides of one Genus. In many of the Scotch series I have found them on *Glauconome*, *Ceriopora*, and *Hyphasmapora*, and it is possible that we shall detect them on other species as well.

I have thus gone over very carefully all the species which I can regard with any degree of certitude as being present in the Shales. The list is a large one for the localities chosen. The abundance of specimens present in a given quantity of material, is small when compared with the Scotch Shales, measure for measure. But few localities, however, in Scotland, rich as they are, have yielded such a variety of distinct types.

I wish to direct the attention of students of Palæontology to the Limestone Shale Beds of North Yorkshire, and in return for material from these beds, I shall feel a pleasure in naming specimens, or otherwise helping in this department of Palæontology any one who is disposed to make a pleasure of work.

DESCRIPTION OF FIGURES.

1.—GLAUCONOME *stellipora.* Young & Young.

2.—GLAUCONOME *stellipora* var *spinosa.* Young & Young.

3.—GLAUCONOME *elegans.* Young & Young.

4.—GLAUCONOME *aspera.* Young & Young.

5.—POLYPORA *tuberculata.* Prout.

6.—HYPHASMAPORA *Buskii.* Etheridge, Jun.

All drawn with the Camera lucida to one scale, magnified about 40 Diams. The varied condition in which the fossils are found has compelled me to give illustrations of ordinary, rather than typical, specimens.

	North Wales.	Hurst and Richmond	Ridesdale, Northumberland.	Gare.	Belstonburn.	Lower L. Shales.	Hairmyres.	Sandstone, Kirkaldy.
GLAUCONOME *marginalis*, Y. & Y.	×	×			×		×	
,, *stellipora* ,, ...		×	×		×		×	
,, var *spinosa* ,, ...		×					×	
,, *aspera* ,, ...		×			×		×	
,, *flexicarinata* ,, ...		×		×	×		×	
,, *retroflexa* ,, ...		×	×	×			×	
FENESTELLA *nodulosa*, Phillips	×	×		×	×		×	×
,, *plebeia*, M. Coy	×	×		×			×	×
,, *tuberculocarinata*, Eth., Jun. ...		×		×			×	
,, *polyporata*, Phillips	×	×			×		×	
POLYPORA *tuberculata*, Prout		×		×			×	
HYPHASMAPORA *Buskii*, Eth., Jun.	×	×	×				×	
CERIOPORA *similis*, Phillips		×		×	sp.			
GONIOCLADIA *cellulifera*, Eth., Jun....		×		×	×			
RHABDOMESON *gracile*, Phillips	×	×	×	×	×		×	×
,, *rhombiferum*, Phillips		×	×	×	×		×	
SULCORETEPORA *parallela* ,, ...		×					×	
CERAMOPORA *megastoma* (*Berenicea*, M. Coy) ...		×					×	
PALÆOCORYNE *radiatum*, Duncan	×	×		×	×		×	×
,, *scoticum* ,, ...	×	×	×	×	×		×	×
FENESTELLA, sp. undescribed		×						

SUBSIDENCES OVER THE PERMIAN BOUNDARY BETWEEN HARTLEPOOL AND RIPON. BY A. G. CAMERON, OF H.M. GEOLOGICAL SURVEY OF ENGLAND AND WALES.

My attention having been drawn to the numerous forms of shrinkage of the land, peculiar to the trend of the Permian boundary between Hartlepool and Ripon, the following paper contains some remarks on these and other subsidences, which have a common origin in denudation, by the action of underground waters circulating in the strata.

At Ripon, the top of the Permian is marked by a number of conspicuous holes or pits in the land, extending down to considerable depths into the rocks beneath.

Between Sutton-Howgrave and Ripon, there are not less than 50 of these pits, ponds and hollows, in a distance of 4 miles; some of these subsidences have taken place within the past ten years, others since the Ordnance Survey of the district, while some remain, of which no record can be obtained. Very interesting accounts of the "Ripon Natural Pits" have been given by the Rev. J. S. Tute of Markington, in *Geol. Mag.*, Vol. v., page 178, and in a paper read at Wakefield at the seventy-third meeting of the Geol. and Polyt. Soc. of Yorkshire.

The top of the Permian first enters the land at Hartlepool, where the Slake is a large "hollow or sinking in the ground."

Adhering to the trend of this boundary are numerous pools, ponds, swamps, and dry peaty hollows, whose configuration appear due to the superficial deposits, settling down into cavities or cauldrons in the rocks on which they rest. Such are the "Hell Kettles" at Croft, Hall Garth, Blackheath, and Queen Mary's Dubbs, near Ripon, and tarn-shaped depressions holding accumulations of black earth, just north and south of Bedale.

The Ripon swallow holes, some of which are said to have once been 200 feet across, and 80 to 100 feet deep, have been attributed to the dissolving away of gypsum or sulphate of lime, or to

the wasting away of the limestone itself. The probability is, that the last named theory is the most correct, for while gypsum is by no means readily dissolved, limestone is readily soluble in water charged with carbonic acid. Where sulphate of lime is dissolving to any extent amongst the rocks, one might naturally expect sulphuretted springs in abundance, whereas there are none, except one now disused and closed up, called the 'Spa well,' near where the Ripon gas house is built. On the west bank of the Ure, opposite Plaster Pit House, there are fine sections of very hard compact masses of gypsum, their crushed contorted appearance being more likely due to the effects of faults passing near than to the river action. Rain then falling on the fissured and porous surface of the strata, quickly percolates beneath, and by its dissolving action, widens the vertically inclined joints, honeycombing it, and leaving in time nothing, it may be inferred, but slender pillars, producing a net work of cells. "A moment arrives when the cohesive force of these pillars is less than the weight of superincumbent rock," (see Prof. Newcomb on the Course of Nature No. lxi Jan. 1879) the pillars fall, followed by the roof they support, the collapse causes at the surface open shafts or pits, engulphing whatever may be on it at the time.

This is in every way specially narrative of the falling in of the Ripon pits, for Mr. Tute tells us that while some farm labourers were at dinner, a hole appeared and swallowed up the hay stack they had been building.

Most of these dangerous holes have appeared suddenly, and without any noticeable disturbance of the surface beforehand.

There are cases in which shallow depressions first form gradually on the surface, these have been noticed to sink 4 or 5 inches in a year. Narrow well-like holes, locally known as "man holes," also appear at intervals, two or three together in one field. These come during wet seasons, and at first contain water, it is thought that a field in turnips after being cleared by sheep is more liable to them than others.

There is one very fine pit in soft brick red sandstone rock, just outside the Railway Company's boundary at Ripon Station. The visible depth is between 30 and 40 feet, but the actual depth probably far more. Water covers the bottom, and is said to flow across, but I have not been able to see any motion in the water. The top of the pit is not much wider than at the water level. The form of the inverted cone is however the usual shape of these pits, as where there is any thickness of soil over the rock, this falls in from all sides and widens the top circumference.

A sailor is reported to have gone down a pit in search of some sheep that had fallen over, and were lost amongst the *débris* at the bottom. He quickly "shouted manfully" to be taken out, there being such a powerful air current as threatened to draw him down the perpendicular opening that was partially choked by the tumbled masses of sandstone.

A pit fell in 10 years ago, on Hutton Bank, after a waggon load of timber had passed over the spot; water remained two or three days at the bottom. The sides are now all smoothed and grown over with grass, and a drain pipe made to run down one side, the contents rapidly disappearing on reaching the bottom of the pit.

In Ripon there are many large hollows that have doubtless once been swallow holes, now cultivated and turned into gardens, and exceedingly beautiful and picturesque they are, with ornamental summerhouses and grottos. Villas and other buildings are fearlessly erected about them.

There are a number of pits or "shoots" as the people call them, about Sutton-Howgrave. A "shoot" took place in a field near the village about eight years since. There is a man living there now, who was in the field at the time of the fall. He told me he heard a noise like the wall of a house falling in; on going to the place, he saw a hole where "water was all bubbling and frothing all over;" this soon quieted down, but there has been a

pond there ever since. From time to time the sides which are of clay, break away and fall in, so that the pond is always being enlarged. There is no indication of it on the Ordnance Maps; when the Survey was going on, no noteworthy, if any pond at all, existed there. At present there is a large pear-shaped tarn stretching nearly across the field, with an outlet on the surface at the narrow end.

Mention has lately been made in the newspapers of a pit, that formed eighty years ago at Littlethorpe, and was accompanied by an explosion, heard at Ripon, fully a mile away. Further south by Bishop Monkton, Staveley and Cawthorpe, there are more of these pits, all of which doubtless have their history.

Newspaper reports also have it, that a crack has been heard in the vicinity of the Ripon swallow holes, a few weeks ago. This being so, the denuding agencies producing the subsidences are evidently no more dormant now than formerly.

In the bed of the Ure below the bridge numerous springs bubble up and burst over the surface of the water. These must take an important part in the subterranean changes that go on.

Pits very near the river are perhaps produced by the river itself abstracting the limestone, and so undermining the sandstone covering, but there are pits on Copt Hewick Moor in sandstone, 150 feet above, and 3 miles from the Ure—measurements almost too great to admit of the supposition that the river had effect in producing them. More likely they are the result of surface water falling on the porous and fissured sandstone, where it forms a thin cover to the underlying limestone, and entering and honey-combing it as already described.

The initiative to a number of the pits may have been given by the river, at a time when confined between high and overhanging crags, as it must once have been about Ripon, it beat ceaselessly against the walls of the narrow gorge, which would become caverned and rugged by the force of the torrent. On the boundary

walls of this ravine the subsidences take place more frequently than elsewhere, this may be due to the strata being in greater dilapidation from the above causes, areas less compact than others determining the locality of the pits.

What appears to me a more probable explanation of the origin of these curious subsidences is, that where the underground water flowing over the limestone surface, reaches the margin of the sandstone, it receives a check whereby it accumulates, forming a chain of dams or pools along the line of junction of these rocks. As denudation proceeds, hollows will form above and below, until ultimately the phenomenon of the pits appears. Should this be so, "the water bubbling up and frothing all over" in newly formed pits, and in wet seasons in those that at other times are dry, is easily explained, without calling in the aid of the river, as after great rains, the superabundant water that has accumulated below would rise to the surface by these vents.

It may be worthy of note here, that in wet seasons at Wells, near Bedale, water runs off a limestone hill, on to a gravel flat, where it disappears almost at once; after a while, a number of dry basin shaped holes in the gravel become filled with water.

A large swallow hole in Ripon is called Salt Pit, but I have no history of it.

The "Hell Kettles" at Croft are two ponds connected by a narrow channel on the surface, situated near to and on an alluvium of the Tees, the water in them may be Tees water, that after traversing the limestone, is conveyed to the pit mouth of these natural shafts or swallow holes. The Hall Garth Ponds, on a terrace of the Ure are very similar cavities the water in them rising and falling with the river.

That something very like a Ripon swallow hole did make its appearance where the "Hell Kettles" are, may be inferred from the following quaint description of a "convulsion of the earth," by a twelfth century annalist.

"In the reign of Henry II, the earth rose on high at Oxen-
"dale, in the district of Darlington, (Oxendale is now Oxney flat)
"in the likeness of a lofty tower, and so remained from nine in
"the morning until evening, when it sank down with a terrible
"noise, to the terror of all that heard it, and being swallowed up,
"it left behind it a deep pit."

With all due deference to our twelfth century annalist, it is not likely that a more interesting phenomenon really occurred than that witnessed by Mr Dunwell, at Ripon, in 1856, and described by Mr. Tute. Mr. Dunwell with his pupils were at the river watching some men fishing, when they heard a noise like thunder, and on looking round, saw at a little distance a mass of earth and stones rising into the air and falling back again. On going to the place they found a hole had formed in which was water; the sides of the pit fell rapidly in, and the water disappeared.

It may not be out of place to describe here the formation of a pit that commenced in the gravelly alluvium of the Clyde. This subsidence caused the inundation of a coal mine, by which four lives were lost, and is known as the "Home Farm Colliery Accident."

A few months after the accident I visited the place with the Rev. James Campbell, minister of Quarter, Hamilton, N.B., who showed me an irregularly shaped hole in gravel, 696 yards round the margin, and about 6 yards from the Clyde. Mr. Campbell afterwards sent me the details I shall now give.

". . . . . . Inundation occurred, Tuesday, 23rd January, 1877.
"First two bodies found Sunday, 27th October, 1878, third on the
"day following, and fourth, on Friday, November 8th, 1878.

"The Home Farm Coal Pit has been worked for thirteen
"years and always considered a very safe pit. The pit is three-
"quarters-of-a-mile from the subsidence. The first indications
"underground of anything wrong, took place eight days before

" the subsidence, when a fall of the roof occurred and water came " in, but not in such quantities as to cause alarm. The morning " of the accident a stronger pressure than usual was felt, water was " seen coming down the heading, and volumes of sand and water " soon began to pour into the workings, to the depth of five feet, " before the survivors had time to reach the cage, which got so " imbedded in the sand, that it was all the engines could do to " move it. The sand and water finally rose twenty fathoms in " the shaft of the pit, or within five fathoms of the Ell Coal.

" There had been very heavy rains and the river had been " higher than usual. The inmates of a house, standing 150 yards " from the hole, said, they were roused from their sleep by a " tremendous noise, and proceeding to the place from whence it " came, found a hole rapidly forming, the sides quickly falling in " all round; sand, stones and gravel came from the sides, and " apparently fell into a hole in the centre; when the sides ceased " to fall in, the cavity filled with water, which appeared to come " from the sides. The area of surface land sunk was about 6 " acres. Upwards of 1,000 great trees and hundreds of bundles " of straw were thrown into the chasm and immediately swallowed " up. The geological formation is stratified sand, gravel, and " stones, (the side nearest the river being all stones) such as " compose a river's bed. Owing to the continuous rains, this " deposit had become so saturated that it broke through to the " workings below. In course of time a pumping engine was " erected, and the cavity pumped dry twice a day; this is stop- " ped and the pit is working again; enormous quantities of sand " and gravel had to be taken out of the workings."

Returning to this district—at Hartlepool the Permian and Triassic rocks dip or roll towards each other, indicating a trough extending longitudinally in the direction of their boundary. If more of these rocks could be seen, those now visible might prove to belong to beds that slope inwards from all round, as they are said to do in the salt districts of Cheshire. There are thick beds

of salt only a very short way from Hartlepool, and it is possible that when the coast line extended further into the present bay, the drainage off the land may have found access to beds of salt below and dissolving them, caused a cavity into which the overlying strata has sunk, giving rise to the large pool or morass called the Slake. A hollow of this kind would retain much moisture on its surface, so that water plants would grow in great profusion, and in course of time would cause the hollow to partly fill up and become a marsh.

Of other subsidences than those connected with the Permian boundary, Mr. Fox Strangways, F.G.S. tells me that in the Middle Calcareous Grit, on Dalby Moor, near Pickering, there are circular holes about ten feet deep, which are caused, he believes, by the solution of the calcareous beds below, most of the springs in the valley beneath being highly charged with calcareous matter and forming great deposits of tufa. These sink holes, if they get grown over with bracken are a source of some anxiety to huntsmen in the district. I am told that an old huntsman in the service of a gentleman at Thornton, rode into one of them, when returning home in the dusk from the hunt. Luckily for himself and horse the pit was a shallow one.

There are a collection of shallow pits on Brompton Banks, Northallerton, called "Soldier Pits," considered by the people to have been places made for defence, but there is more reason to believe they have been workings for gypsum or other mineral.

The Rev. Mr. Atkinson, of Danby, considers the pits about the base of Roseberry to have been the results of former mining enterprise, and that many of the alleged British villages may have a like explanation.

In *Geol. Mag.*, Vol. viii, page 312, July, 1871, I have described a large swallow hole or cavern in the carboniferous limestone at Stainton-in-Furness. Hidden away in a limestone hill are three large dome shaped cavities, one over the other, and

connected by short passages or narrow slits in the strata. The approach to the uppermost cavity being a subterranean tunnel 235 yards in length. This tunnel was discovered by the blasting of the limestone in an adjacent quarry. The walls of the cavities bear signs of having at one time contained water, that having rushed along the waterways, whirled about inside, until finally, either from the supply ceasing, or being diverted into another channel they became empty. Inside were some boulders of igneous rock, *in situ* some four miles distant, a few small bones and and traces of hematite. The surface of the hill is bare limestone, very much fissured and channelled, abounding in the hart's tongue fern.

In Furness the hematite is found in "sops" or pockets in the limestone, which if they happen to be at the surface, admit of the ore being dug out with a spade as clay is at a brick yard. The "sops" maintain a determinable course though they are often far between each other, and are probably swallow holes that formed when the limestone was as yet uncovered by the ferruginous sandstone that afterwards filled them up with ore, or they may in some way be the result of the bulging out and contraction of the hematite itself.

Subsidences have recently occurred at Blackheath, near London. They first began in 1878, after an extraordinary flood, more appeared in November last. They are from fifteen to twenty feet deep, and are in the Pebble Beds overlying Chalk, that constitute the Blackheath plateau, near to the river. Mr. T. V. Holmes, F.G.S., has given interesting accounts of these pits in the "Engineer," March, 1881; and Mr. De Rance, F.G.S., in "Nature," in February, 1881. From these we learn that the water level of the chalk is considerably below the bottom of the pits, and the gravel too thick to admit of them being pipes in the chalk.

Mr. T. V. Holmes, late of the Geological Survey, has forwarded me the Report of the Committee for the Exploration of

the Subsidences on Blackheath. The results of the Exploration are greatly in favour of these Subsidences being due to artificial, rather than natural causes, an opinion borne out by Professor Prestwich, and expressed also by Mr. Whitaker, of the Geological Survey, at the Meeting of the British Association, in York, 1881.

A PRELIMINARY ACCOUNT OF THE WORKING OF DOWKERBOTTOM CAVE, IN CRAVEN, DURING AUGUST AND SEPTEMBER, 1881. BY EDWARD B. POULTON, M.A., F.G.S., OF JESUS AND KEBLE COLLEGES, OXFORD.

AT a meeting of this Society, held at Sheffield, on December 14th, 1859, Mr Henry Denny gave an account of the working of Dowkerbottom Cave. The exploration had been conducted at different times by Mr. Jackson of Settle, Mr. Farrer, and Mr. Denny himself. At a subsequent meeting, also at Sheffield, on March 9th, 1865, a paper on the same subject was contributed by Mr. J. Farrer and Mr. Denny. Since this last paper was read, sixteen years ago, till the past summer, the cave has been left entirely alone; and in renewing this long neglected search I have been especially helped in having before me an account of former work in the "Proceedings" of this Society. The work that has been done this summer, with the advantage of so many examples of scientific cave-working, tends to confirm some conclusions formerly arrived at, while others require modification. It was therefore in every way right that I should accept the kind invitation of your Secretary to read a paper on these later researches.

It is first necessary to describe the condition of the cave; and in doing so I will quote from a paper read at York, to the Geological Section of the British Association, and written by me while the work was in progress. This account, although read, has not been published.

Dowkerbottom Cave is situated about a mile S. of Hawkswick, and a mile-and-a-half N.W. of Kilnsey. It is 1250 ft. above the sea, on a terrace of the steep slope of mountain limestone, which to the N.E. descends to form the moraine-covered S.W. bank of the R. Skirefare, while to the S.W. it rises higher to an extensive moorland from 1,500 to 1,600 ft. above the sea. The cave itself opens on a level terrace, covered by grass, and sheltered on nearly all sides by rising walls and slopes of weathered limestone. Even on part of the slope towards the river is an outlying mass of rock which rises far above the level ground on which Dowkerbottom Cave opens. The present mouth of the cave is very remarkable. At the bottom of a hollow in the terrace, with gently sloping sides covered with turf, and invisible until one is standing almost on its edge, is a narrow cleft in the limestone, almost filled with angular blocks which form irregular steps downwards at either end of the fissure. At a depth of about 30ft. each of these flights of rocky steps ends in a cave. This mouth is obviously secondarily formed and represents a fall in the roof at some point where the rock thinned away above by successive smaller falls. Such falling in of the roof must be expected to occur again, and in one place especially, where very few feet of rock intervene between the turf and a spacious chamber nearly 40ft. in height.

At York I expressed the opinion that the true mouth of the cave would be found in a slope 250 ft. S. of the present opening and terminating the western and smaller division of the cave. We were enabled to verify this conclusion before leaving the work. The physical features of the cave are as follows. (See Fig. 1.)

From the steps at the E. end of the fissure, a slope of *débris* leads into a chamber about 50 ft. long and 25 ft. high. There is a sudden turn to the left at the end of this chamber down a short and narrow passage which opens into a far finer and loftier chamber 70 ft. long and 37 feet high in one place, 36 ft. over a

large part of the roof. In descending from the general level of the terrace, down the slope of the hollow and down the rocky steps, so as to be well within the roof of the first chamber, one has come down 23 ft.; from this point, down the talus and into the second chamber is a further descent of about 22 ft. Thus the floor of the second chamber is about 45 ft. from the ground above, and the roof being 37ft. high, it follows that only 8ft. of grass, earth and rock form the roof of this chamber. At the further end of the second chamber is a passage upwards, down which a small stream runs and loses itself at the entrance into the chamber. The passage ascends 18 ft. in a distance of 72 ft., and is tolerably broad and high. It then soon becomes very narrow and difficult to pass, and contains water in parts which was nearly 3 ft. deep till we lowered its level by cutting away the rocks at the entrance to this gorge. From the last point to the end of the gorge is a length of about 100 ft., and altogether there has been a very slight rise. At this point the third and last chamber begins. It is about 160 ft. long and slopes very gently downwards as far as the beginning of the last 30 ft, where the descent becomes rapid and leads down to a small pool about 3 ft. deep. At the further end of this pool the walls of the cave unite, presenting at their junction step-like irregularities. The total length of this division of the cave is 463 ft. 6in., and in this length are three chambers, and two passages; a very short one from the first to the second chamber, a very long one from the second to the third.

The first chamber has been thoroughly worked in its upper layers at any rate, in the former explorations, about 22 and 16 years ago, by Mr. Jackson of Settle, Mr. Farrer and Mr. Denny. The original state of the floor is now entirely obscured by the *débris* of former workings. In a drawing published in the "Proceedings" of this Society, illustrating Mr. Denny's paper, this chamber is shown to have a layer of charcoal 2ft. thick on the floor, in which, as well as in the first chamber of the W. side, most of the celebrated remains were found. The second chamber was

formerly covered by hard stalagmite deposited by the stream which then flowed across the chamber and lost itself under the right wall. This stalagmite was removed in the explorations mentioned above, and the stream disappears below the broken edge of the hard stalagmite at the further end of the chamber. The present floor of the chamber is chiefly of hardish stalagmite; in various parts are the traces of former working, but most of it has not been touched, after the removal of the hard stalagmite. This floor will be described more in detail when I speak of our work in this chamber.

The steep passage at the end is of hard stalagmite, while at the top where the stream receives many additions from the sides, the stalagmite is softer. The gorge further on supplies the water which forms the head of the stream, for the latter begins in the overflow from the gorge, while the gorge itself is fed by little springs along its sides. In the gorge thickened walls of stalagmite make a very narrow passage in the lower part, while above these walls end as two ledges which used to be the only foothold in passing to the next chamber.

The third and last chamber is very different from the others. It deserves a special description, as its present state explains in a most interesting way the former condition of other parts of the cave. Its roof is flat and not lofty,—about 15 ft. in height. On the floor are thickly strewn large angular blocks of limestone, which have fallen from the roof from time to time. These falls have not been of very recent occurrence for on the rough surfaces and sharp edges of the limestone blocks, rounded projections and flattened layers of stalagmite are seen, caused by the drip from the roof. Between and beneath the blocks is an extremely tough brown clay, especially abundant at the further end of the chamber. I have mentioned a small pool at the end of this chamber; but marks on the walls shew that quite recently there has been a subterranean lake, at least 12 ft. deep in parts. This must be the lake spoken of in Whittaker's "History of Craven," and described as preventing the complete examination of the cave. Probably

some passage has been gradually dissolved away, and the lake drained, or a system of fissures supplying it with water may have become choked.

Thus the deposits in this third chamber are chiefly mechanical in origin, consisting of the blocks fallen from the roof, and the stiff clay derived from the finest sediment slowly brought through narrow fissures to a lake in which no perceptible currents can have been present. Chemical deposits, represented by stalagmite, elsewhere so abundant and thick, are only present as thin layers on those parts of the limestone blocks covered by the water of the lake and not sunk in the clay, and also where deposited by the drip from the roof upon the parts not covered by water. There are also very small stalactites on the roof, and thin layers of chemically formed limestone on the sides. It will be seen that chamber 2, now so different, for a long period resembled this chamber in the preponderance of mechanical over chemical deposits.

The western division of the cave is far smaller than the other, it also consists of three chambers separated by two passages. The first chamber much resembles that on the E. side, only it is smaller. Its former condition is shewn in the section appended to Mr. Denny's paper, and exactly resembles that of the E. side; the surface being covered by what is called a "charcoal layer." From the first chamber a narrow winding passage leads to the second chamber from which it is separated by a constricted aperture; the floor of this small chamber is composed of hard stalagmite. Then follows a fall of the roof, the blocks firmly embedded in a large amount of hard stalagmite. In the upper part of this fall is a passage to the third chamber. The further end of this chamber, of which the floor is also covered with hard stalagmite, narrows to a mere fissure filled nearly to the roof with fallen limestone blocks, along which one can make way for a few yards. The true floor at this end of the chamber is concealed under a vast heap of fallen blocks.

In the western division no clay appears on the surface and mechanical deposits are represented by fallen blocks only; at the further end of the last chamber it seemed likely that the true mouth was very near, but blocked by stones and earth. We therefore began work from the inside, and found that the rounded limestone blocks which abruptly closed the chamber were very loosely imbedded and easily removed. We soon found that the roof was absent in front of us, ending in a vertical cliff. Fixing a bar across the passage for protection, we brought down the blocks and earth by means of a long pole, and gradually worked the hole upwards; we then found the spot on the ground above, by listening for the sound of hammering below, and dug downwards. After 3ft. of clayey soil there was an empty space caused by our working below. After clearing out the opening we found that the vertical face in which the roof ends is 20 ft. high. The side walls of the cave continue onwards as a ravine for about 50 ft. to the slope, entirely filled with the loose mixture of earth and stones and only discernible on the ground above by its covering of unbroken turf. There was not sufficient evidence to determine whether this loose material was of glacial or alluvial origin, or whether the mouth was artificially closed by it. Future investigation must determine this by clearing out the ravine and working the cave from its true entrance. In this way all windlass work will be dispensed with, and many interesting questions settled. Just opposite the slope where the ravine must open and about 50 yds. distant, is a pot-hole in the lowest part of an extensive hollow. It is extremely likely that there was formerly a connection between this and the cave, by a passage, now denuded away. The cave would then have drained into the pot-hole; and the stream on the eastern side is in this direction, although it stops short at the second chamber. This may be due to the gradual widening of a fissure by solution, but it is possible that the water from the cave still finds its way by a lower system of passages to the pot-hole. The same thing may be true of the

western side, where the water in wet weather drains *from* the third and second chamber to disappear in the first passage. These superficial changes in the course of the currents appear to be due to falls from the roof.

The direction of the W. division of the cave is at right angles to the slope in which it opens, and is marked by a longitudinal depression, so that the slope is less steep at that point. The roof at one time must have extended to the slope (and much earlier, probably to the pot-hole) and since then it has been gradually removed by successive falls, while the side walls remain as the ravine. The *débris* of the roof are not visible in the section exposed, and they probably exist at a lower level. All the stones observed in the accumulation in the ravine, were rounded. Many very interesting facts have yet to be investigated concerning this true opening; especially as to the time when it was used relatively to the present or secondary mouth, and also as to its extension towards the pot-hole. In the latter case we may expect to find cave deposits beneath the grass of the hollow, between the cave and the pot-hole.

With regard to the use of either opening. nothing is yet certain, except the fact that the human occupiers of the cave in Roman and post-Roman times used the present mouth. This is proved by the abundance of remains indicating the presence of man in the upper layers of the first chamber on the E. and W. side, and their absence as far as I have observed in the W. side, past the first passage.

Thus Dowkerbottom Cave, when it opened at the slope had six chambers and five passages. Since then this mouth has been blocked up and a new one has been formed by the falling of one of the passages.

I will now give a short account of the evidence borne by the cave itself as to former explorations.

The first chambers on both sides have been thoroughly

looked over (at least as far as their surface layers are concerned) and here were obtained the coins, fibulæ, pottery and various implements of bronze, iron and bone, and also the bones of animals which are usually found accompanying such objects. Remains of this kind will probably never be found in the same abundance in the other chambers which are of course less accessible from the present opening. The second chamber on the W. side is only approached by a narrow and difficult passage, and that on the E. side with its lofty roof so near to the grass above, drips very unpleasantly in wet weather, and would probably be little used in comparison with the outer chamber. We have abundant proof that the drip was extensive in former days, by finding numerous polished pebbles of stalagmite in the same layer with the implements and pottery, exactly similar to those now forming in the cavities on the floor, and due to the same cause. Probably owing to the uncommon form of entrance none of the *débris* of former workings was removed from the cave, and thus a systematic investigation was impossible. The passages from the first chambers on both sides have also been turned over for specimens. In that on the W. side some human skeletons were found by Mr. Farrer's workmen, apparently in a grave. Other human bones are described in the papers of this Society as coming from the cave, but with this exception the places are not specified; also the sections dug and shortly described are never clearly referred to their position in the cave. The W. division has not been touched past the first passage. In the E. division the second chamber has been worked in various parts, and its covering of hard stalagmite entirely stripped off. It appears as if the workers had not found the work here so remunerative as in the other chambers, and had abandoned it after a few slight attempts. From the beginning of the second passage the cave appears to be untouched except for a hole or two dug at the top of the slope down which the stream descends, at a distance of about 70 ft. from the second chamber.

It now remains to describe our own work in the cave, and

before doing so I wish to thank J. R. Tennant, Esq., of Leeds, and J. R. Eddy, Esq., of Carleton, Skipton, on behalf of the Duke of Devonshire, the lord of the manor, for kindly allowing me to work the cave, accompanied only by the condition—which I am only too pleased to accept—that the specimens found shall not ultimately go out of Yorkshire. Especially I wish to thank Mr. Eddy for his kind help and advice in the work, without which I do not know how we could have overcome the great practical difficulties in blasting and other heavier parts of the work needing experienced hands. I must also perform the pleasant duty of thanking those gentlemen who have helped me in the work during August and September, and who have, I hope, gained as much by the change of scene and occupation as by the more customary modes of spending the long vacation. I am glad to mention the names of those who have helped me:—Mr. A. T. Martin, of Worcester College, Oxford, and Clifton College; Mr. Gell, of Balliol College, Oxford; Mr. Jackson and Mr. Scattergood, of Queen's College, Oxford; Mr. Waugh, Mr. Grinstead and Mr. Crouch, of Keble College, Oxford; Mr. Fitton, Mr. Cürtoys, Mr. Horniblow and Mr. Scott, of the Oxford Military College, at Cowley; and Mr. Walker and Mr. A. S. Smith.

By taking bearings and measuring we found that the E. division curves round under the high ground to the N.W. A windlass was put up over the first chamber at the E. end of the entrance; and below, the talus accumulated to depth of 10 ft. was dug away to make a way for the barrows to the foot of the slide leading up to the windlass. A very interesting fact was here discovered. The black so called "charcoal layer," mentioned in Mr. Denny's and Mr. Farrer's papers, was found to be continued under the talus, although in the section mentioned above it is drawn as ending at, and above, the foot of the talus. As the black layer came into view I had it carefully removed and sent to the surface for examination. During this removal many bones were found which now await identification, and other specimens which

indicate the age of the layer, and prove it to be of the same date as the historic layers in the Victoria Cave. As bearing upon attempts to fix dates by comparing thicknesses of talus, it is interesting to note that the Victoria Cave layer of this age was covered by a slight thickness of talus derived from the weathering of a lofty cliff freely exposed to the air, while in exactly the same time the Dowkerbottom talus had reached a thickness of 10 ft. from the weathering of a very small surface of comparatively protected rock. No doubt the difference is exaggerated by the restricted space with a tolerably level floor into which the talus fell in the latter instance.

A great many bones were found in the talus itself, among which the Red Deer and Boar are conspicuous.

The second chamber I have already mentioned as little worked, and we determined to begin here. The first passage was blasted to allow the ready transit of barrows from the second chamber to the foot of the windlass. The chamber itself was marked off into parallels at right angles with a datum line, and these again were divided into squares by lines parallel with the datum line. The lines in both these sets were 1 yd. apart (see Fig. ii, Ground plan of Chamber). As all previous work had been at the sides, and was not likely to lead to results typical of the whole chamber, I determined to sink a shaft in the very centre. The result is that the section obtained, entirely differs from those drawn by previous explorers. On many parts of the surface is a layer from one to nine inches thick, of a blackish earth, containing pottery, bones, and in some cases metal implements. This is the historic layer and corresponds with that in the first chamber in its remains, although it is apparently developed to a less extent. In one place, very nearly in the centre of the cave (in parallel J, Square 5, Fig. ii) the layer is let down into a circular pit about 1 yd. across, and certainly dug by the men who lived at the time when the layer was being formed. The pit is about 4 ft. deep and its sides are quite smooth and sharply demarcated

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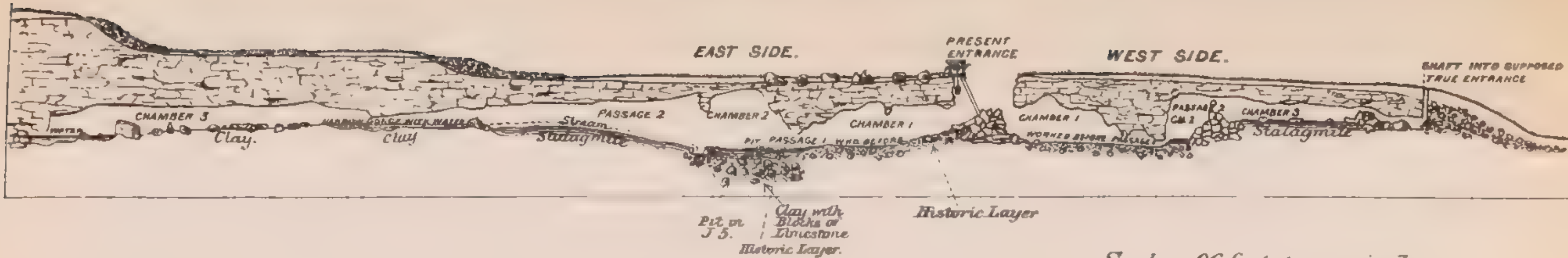
Fig. 1. Longitudinal Section



Scale - 96 feet to one inch.

Fig. 2. Ground Plan of Chamber 2. (East Side)

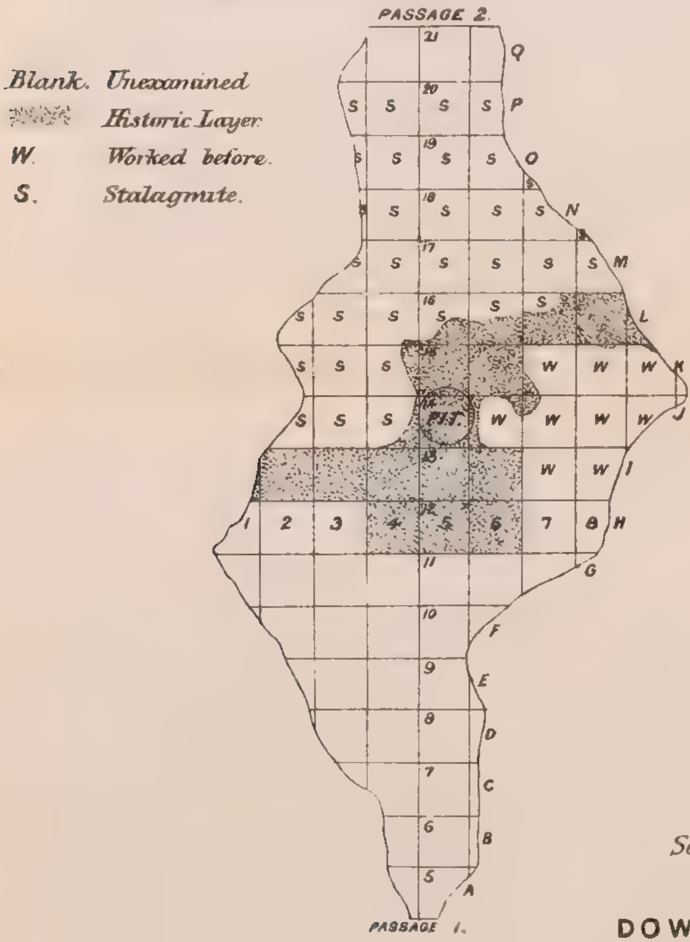


Fig. 3. Section across Chamber 2 (East Side) between parallels K and L.

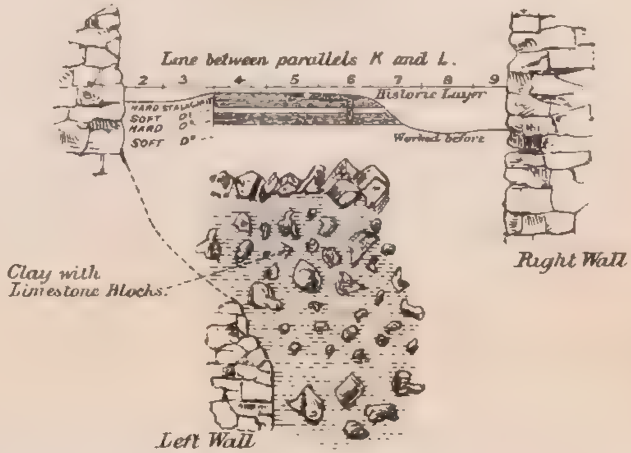


Fig. 4. Section across Chamber 2 (East Side) between parallels M and N.

Scale - $\frac{1}{12}$th of an inch to the foot

DOWKERBOTTOM CAVE.

from the contents. In fact I cleared out the latter, finding many interesting specimens, and the walls of the pit remained firm until it was necessary to destroy it in further work. The pit is dug in soft stalagmite and the sides exhibited cracks which did not extend into the contents. The stalagmite is stained dark by the blackish earth which is the chief part of the contents. This earth was mixed with soft stalagmite, and lumps of limestone generally covered by hard stalagmite. The color of the whole contents was greyish. In addition to the above proofs that the pit was of ancient formation, the remains found also pointed to this conclusion. The bones and ornaments were frequently incrusted with stalagmite, and evidently in the position they occupied when thrown into the pit. Three small bronze pins were found in the pit and they were all close together, and were found within a few minutes of one another, although the examination of the whole contents occupied three or four days. The pit may have been dug for rubbish and some useful and ornamental objects may have dropped in accidentally, as is generally found to be the case in ancient rubbish heaps. Half of a broken spindle whorl of Samian ware was found in the pit. The article itself was an instance of the utilization of rubbish, being roughly made out of a broken fragment of pottery ground into a rude disc by rubbing on a stone, and pierced in the centre. After the breakage, half the spindle whorl was thrown into the pit as being of no further use. One small piece of flint was found near the pit in a greyish layer of the same age as the black earth. It may be an instance of the survival of an ancient form of implement. It appears to be a broken flake and shews distinct signs of working. Among the curiosities of these upper layers is an old-fashioned, but not ancient pin with the head formed in the old way. Very many rubbed and cut bones were found, probably some were used as handles, others as knives, while others again appear to be small pegs or perhaps rough pins. By far the most interesting implement of bone was the bowl end of a spoon-shaped fibula, pierced

by a central hole, and ornamented with circles with dots in their centres. Gnawed bones were also found, the marks being caused, as far as I have observed, by a small rodent, probably the field-mouse. This animal is not mentioned as before found in the cave, but both in the black earth generally and especially in the pit, the number of teeth found is so great as to suggest the idea of the animal having been used for food.

The chief implements or ornaments of metal are as follows They were all found in the pit or the black earth of the same age Two bronze brooches, one circular and one oblong, underneath both are traces of the hinge for the pin (and part of the pin in one case) and the catch; two bronze rings one of which, not larger than a finger ring, is expansible; an interesting iron pendant ornament with bronze bands on it; one bronze needle; iron nails are not uncommon, and lumps of iron of which the shapes do not indicate any use; one fine iron bracelet was found, and portions of fibulæ and rings; there was also found a twisted piece of lead which may not be ancient, although the position, depth, and condition are in favour of this view; it was found at a depth of 1 ft., close to a burrow containing rabbit bones of recent date; two green-stained bones were found, and no bronze was near either of them to impart the color. Fragments of pottery are very abundant though never large: they consist of a coarse black ware,—sometimes with diagonal lines marked on it, cutting one another to form a diamond-shaped pattern,—and also of three kinds of red ware, among which Samian is the commonest. I believe that careful comparison of the pottery found, will shew a great difference in the dates of occupancy of the cave although all the fragments came from one layer. In connexion with this is the fact that worked flint was found close to finely formed bronze and iron implements, evidently of Roman or post-Roman age. It is very probable that the bones will also indicate the same heterogeneous origin of the layer in which they were found. Bones were extremely common in the greyish layer, generally in excellent

condition, and often covered by stalagmite; teeth were also abundant. The animals were those usually found accompanying deposits of this age, but I think it likely that identification of the specimens may shew some more exceptional, or older forms.

The intermixture of remains in these upper layers may be due to the stream which once flowed across the chamber, and must have brought down remains from the higher parts of the eastern division. In favour of this view is the conclusion arrived at after working the Victoria cave at Settle: that the older and newer remains are intermixed in the innermost parts of the cave, although separated by a great thickness of intervening deposits towards the entrance. It is also noteworthy that many of the remains, especially pottery, are distinctly waterworn, and that the stream in wet weather comes down with force enough to bring any of the remains found in these upper layers.

I may add, that it is chiefly because of the impossibility of confirming these conclusions that I am obliged to make this paper a preliminary one.

The comparison and identification of the remains found in the upper layers must be a work of months, but I have given above a short account of what I believe will be the conclusions arrived at by the work.

Indications of fires were found commonly in the black layer and the pit, chiefly as fragments of charred wood. Pot-boilers for heating water in vessels that would not stand the fire were found in these layers. A fine example of these round stones of micaceous sandstone, covered by stalagmite, was taken from the bottom of the pit; a slab of sandstone also covered by stalagmite and used for baking cakes, as Professor Boyd Dawkins kindly informs me, was found in the pit. The limestone so abundant around could not have been used for these purposes, as it would not stand the fire, therefore the dwellers in Dowkerbottom cave probably brought their pot-boilers from the bed of the Skirfare

nearly 600 ft. below. A small piece of baked shale is also interesting, as I believe none occurs nearer than the summit of the other side of the valley of the River Skirfare, although the brown clay of the deeper layers in the cave may have burnt into a laminated mass like that found. Fragments of charred bones are also common.

The distribution of the black layer containing these remains is very variable, sometimes being on the surface, sometimes 1 ft. below soft trodden stalagmite. In some cases it had been carried down into small pipes in the soft stalagmite beneath, caused by the drip from the roof. In one place a perfectly vertical, circular hole, 3 in. in diameter, and 1 ft. deep, had been drilled for some unknown purpose in the soft stalagmite, and became filled with the black layer (See Section in Fig. iii) : in another instance, a still larger and deeper hole was found.

At first, in the centre of the chamber (parallel K, squares 4, 5, 6, Fig, ii) we dug below the black superficial layers ; first we passed through a layer a few inches thick, of hardish stalagmite, easily yielding to the pick : then through a few inches of soft stalagmite, and again of hardish, and then of soft stalagmite. This character was maintained over a large area, and stretched from one side of the cave to the other (See Fig. iii and iv). The soft stalagmite could readily be dug out with the spade. The first three of these layers were thin, the last, the lower soft stalagmite is far thicker, and carried us down to a depth of 4 ft. Here large blocks of limestone appear, incrusted with hard stalagmite ; below this horizon all chemical deposits cease, and those of mechanical origin alone succeed. In fact, the second chamber appears to have resembled, on a far larger scale, the present condition of chamber iii. For a depth of 10 ft., and probably more, there succeeds an extremely tough, stiff, brown clay, in which huge blocks of limestone are abundant—rough and angular, and uncovered by stalagmite (See Fig. iii). This combination of the huge heavy masses imbedded firmly in an adhesive flexible cement, was

a serious impediment to the work, and many of the blocks had to be broken before they could be got out of the pit.

At a depth of 12 ft. the left wall of the cave was found sloping downwards (Fig. iii); this was followed for 2 ft. more, and had then taken a vertical direction. Beneath this thick bed of mechanical deposits it is quite possible that the older cave earth exists. I am certain that the former accounts are in error in describing a floor. They met with the blocks above the clay—some of them very large—and mistook these for the floor. In fact in the diagram appended to Mr. Denny's paper, the clay itself is entirely omitted, and the limestone floor is placed beneath the soft stalagmite in the section of this chamber. We should most certainly have dug through the clay, and settled the question of the older cave remains in this chamber, had it not been for the constant stoppage due to water. Quite half the labour expended this summer was rendered fruitless in this way. Sometimes the pit was filled with rain water that came in large quantities through the roof in wet weather, but more generally our work was stopped by striking a spring. We attempted to complete the section at nearly all points along parallel K, that is, right across the centre of the chamber. In one case, under the right wall we dug 10 ft. through soft stalagmite, and then, apparently on the surface of the clay, we came on a spring preventing further work. The right wall extended downwards quite vertically as far as we exposed it. The clay was shewn to be far deeper at the right side, and the stalagmite much thicker (See Fig. iv). This character we also detected in other sections. There are many curious water-channels in the stalagmite, generally dry, but full of water in wet weather (Fig. iv); they are principally developed between the stalagmite and the clay. In the higher parts of the soft stalagmite are burrows containing rabbit bones; some of these burrows appear to have been adapted from dry water-channels.

No remains of any kind were found in the layers below the black earth, except in the hard stalagmite immediately below

it. In this layer, at one spot, the remains of a dog or wolf are common, and in excellent preservation. They are distinctly older than the historic layer. Thus the condition of this chamber seems to point to the impossibility of its having been inhabited during the deposition of the layers that we met with in our deep sections. At this time it seems to have held a deep still lake, at the bottom of which slowly accumulated the brown clay, gradually covering up the limestone blocks which continually fell from the roof. At length the condition changed, after 10ft. or more of clay had been formed. The supply of water to the lake increased, and caused its overflow, perhaps due to the increased rainfall, or to the opening by solution of additional fissures; or possibly the lake broke through one of its boundaries. However caused, currents must have established themselves in the previously still water, and the supplies of sediment were hurried away to be deposited elsewhere. Stalagmite was deposited on the blocks last fallen from the roof, and lying on the top of the clay, and layers of soft and hard stalagmite succeed, probably due to varying rapidity in the rate of deposition, as suggested by Mr. Farrer in his paper.

This physical history, shewn by the deposits cut through in the section, is especially interesting in the complete and distinct demarcation between a mechanical and chemical origin, so plainly shewn. The falls from the roof seem to cease at the surface of the clay, for no blocks (except just above the clay) were found in in the soft or hard stalagmite, although we have almost entirely removed it over a considerable portion of the floor.

The following explanation may account for the sudden absence of falls from the roof. The same water, which—carrying an excess of bicarbonate of lime in solution—deposits it on the rocks and in layers on the floor, would also deposit cement between, and upon the limestone blocks of the roof, and hold them firmly together. Indeed it is very common in this and other caves, to find blocks of limestone held firmly by stalactite alone, sometimes in apparently most precarious positions, as when they

have slipped downward from the roof, and only rest against the two vertical sides of a passage. It is well known that the power of dissolving and therefore depositing carbonate of lime, possessed by water, depends upon the carbon dioxide which it has taken into solution. This is derived almost entirely from the soil. The soil in yielding this gas again depends upon the growth and death of plants and animals. For a long time after the Glacial period, the Yorkshire hills must have remained bare of their vegetation, and they would also have almost certainly lost the vegetal soil they may have possessed before. Thus would be produced conditions most unfavourable to chemical deposits, and most favourable to those of mechanical origin,—in the absence of cement between the joints of the roof, and in the very heavy rainfall which is believed to have followed the Glacial epoch and to have formed a Pluvial period.

We also made some attempts on the western side. The first passage was blasted and made readily passable, and we set to work on the small second chamber which had not been touched before. Here in the upper part were deposits from running water,—sand clay, and stalagmite. There was a distinct stratification due to the running water. Among these deposits were many bones and teeth which await identification. As far as I examined the remains, they were of wild animals, and one piece of pottery alone indicated the presence of man; it was probably brought to this position by water, and many of the bones may have been also washed in. Beneath these upper layers were large blocks from the roof imbedded in stalagmite; some of these projected through the upper layers, while the latter were a foot thick in some places.

Thus in all our work at Dowkerbottom Cave we found (as far as I have yet seen in the remains) no proof of the existence of the older cave fauna, while on the other hand, we found distinct evidence that others who describe complete sections without such remains were mistaken in their conclusions. Some authorities have brought forward the peculiar form of entrance, and the narrow

passages of the cave, as evidence that the older animals could not have inhabited it. But on the other hand we have shewn firstly, that the present entrance was not the original one, and that the cave possesses a mouth of the usual kind, and secondly, that the cave deposits are of great thickness, so that a narrow passage may become a lofty chamber at the horizon of the older fauna. In fact the present floor is manifestly in many places, raised by falls of rock, almost to the roof. Thus while there is no evidence for the existence of the older remains, there is no more reason to doubt their presence, than in the other caves of Craven now known to contain them. They were found in abundance in one chamber of the Victoria cave, in which the cave deposits nearly touched the roof, before the exploration began. I much hope that next year it may be my fortune to decide the question, which is of extreme interest, whatever be the conclusion arrived at. In the meantime the upper layers have yielded many interesting specimens, and the whole work of the past summer has enabled us to trace a great part of the physical history of the cave.

VESTIGES OF THE ANCIENT FOREST ON PART OF THE PENINE CHAIN. BY JOSEPH LUCAS, F.G.S.

It should be premised that the following sketch is drawn up from a voluminous series of notes, jotted down upon the 6in. ordnance maps (which are contoured at 25ft. intervals), during the progress of the Geological Survey of the district, 1869—1872. The description principally refers to the basins of the Nidd and of the Burn.

Nidderdale and its moors have formerly been covered by an extensive forest. Many trees, long buried in peat, are exposed in the thousands of sections made by little watercourses on the moors. The Birch appears almost everywhere predominant. Hazel, Sealh (Willow), Thorn, Oak, Alder, and other trees also occur, but the Birch evidently formed an extensive forest by itself,

such as may be seen on the west coast of Norway at the present day. The upper parts of the moorland gills, and much of what is now the moors, must formerly have made a beautiful appearance with its light gauze-like forest of Birch and Mountain Ash. The last surviving example, on any considerable scale, is preserved in Birk Gill, a tributary of the river Burn, which runs N.W. to S.E. The Gill is about 400 feet deep at its mouth (the bottom of which is 600 feet above the sea), and half a mile wide from ridge to ridge. Like all other valleys at the same elevation in these hills, it is boat-shaped in section, the beck running in a deep ravine at the bottom. There is no cultivation in the Gill, the sides of which are wild heathery moorland, crowned with fine lines of crags down to the edge of this ravine, in which the native forest is preserved. The belt of wood clothes the sides for 200 feet or up to 800 feet near its mouth, and ends where the beck reaches 900 feet, in a distance of rather over a mile. Above this point the stream is called Barnley Beck. The wood consists of Mountain Ash, Alder, Oak, Ash, Birch, Holly, and Thorn, and runs above the edge of the cleft with a delightfully irregular and feathery margin, on to the ling-covered moor. Above 900 feet the stragglers were all noted, the highest living individuals of each kind of tree being as follows. (The full details of all the observations will be found in my "Studies in Nidderdale," xiv. 3. Thorpe, Pateley Bridge.) *Barnley Beck*, S.W. and N.E.—Oak, 900; Alder, 950; Salix, 1050; Thorn, 1080; Birch, 1125; Holly, 1150; M. Ash, 1175. *Scale Gill*, tributary of Barnley Beck, N.W. and S.E.—Thorn, 1100; M. Ash, 1175, highest living tree. The Gills in Colsterdale present a similar picture. *House Gill*—M. Ash, 1150, highest living tree. *New House Gill*—M. Ash, 1175. *River Burn*—Thorn, 1175, on tongue at junction of Long Gill. *Long Gill*—Birch, 1175; M. Ash, 1250, highest living tree. *Backstone Gill*—M. Ash, 1275, highest living tree. *Steel House Gill*—M. Ash, 1375; Bullace, 1375; together on Moor, at edge of Gill. *Thorny Grein*—M. Ash, 1200, highest living tree.

Deep Gill—M. Ash; 1255. All the above are in the Colsterdale basin, or the basin of the River Burn. The extreme points are found in Nidderdale. Before giving these, and proceeding to a comparison of the highest elevations at which these several trees now grow, with the height at which their remains lie buried in the peat, it is desirable to premise that the highest six miles of Nidderdale runs due east from Great Whernside, and that the northern edge rises 400 feet above the Nidd, being distant from the river three-quarters of a mile. This slope has a northerly curve, the greatest convexity towards the north being at Lodge and Woo Gill. Lodge owes its existence, as a farm, to this fact; and the fields of Lodge Farm are the highest anywhere in the district, their upper edge reaching 1500 feet above sea level. In this grand southerly concave slope, Woo Gill runs as a deep cleft to the north. The shelter from the north and east winds, and the sheltered exposure to the full warmth of the southern sun, has preserved in Woo Gill several relics of the ancient forest at higher elevations than they are found anywhere else in the district. Thus—Birch, 1275; Hazel, 1350; Salix, 1375; M. Ash, 1600, highest living tree. Gill gets out on to moor.

I will now present the elevation of the highest stragglers of each kind of tree, up the various moorland gills and becks, including the district east of Nidderdale.

BIRCH—NIDDERDALE—Arna Knab Wood, 1000; High Scar (Backstone Gill), 1100; Woogill, 1375. COLSTERDALE—Long Gill, 1175. EAST OF NIDDERDALE—Foul Sike, 875, with M. Ash, Alder, a few feet below; Cot Gill, 850, open ling covered moor, 24 feet below are two Thorns and a Hollin; Carlesmoor Beck, 800; Far Beck, 900.

MOUNTAIN ASH—NIDDERDALE—Woo Gill, 1600. COLSTERDALE—Scale Gill, 1175; Backstone Gill, Long Gill, 1350. EAST OF NIDDERDALE—Skell Beck, 900; Carlesmoor Beck, 875; Foul Sike, 875; Trib. of Wandley Gill, 975.

THORN—NIDDERDALE—High Scar, Backstone Gill, 1100; Greenhow Sike, 1050. EAST OF NIDDERDALE—Cot Gill, 825; Sike from Sandwith Wham to Stock Beck, 800. COLSTERDALE—Long Gill, 1175; Scale Gill, 1100.

JUNIPER—NIDDERDALE—Lul Beck, 925.

HAZEL—Woo Gill, 1350.

Dead Birch stems abound in the peat, from 1000 up to at least 1725 feet, as at Little Blowing Gill Beck, and Sandy Sikes Gill, and no doubt much higher on these same moors. (For full details see "Studies in Nidderdale," pp. 114, 115.) In like manner it will be observed that the highest living Hazel is in Woo Gill, at 1350 feet. But there was a time when the Hazel not only grew, but ripened its nuts, at 1650 feet, on the moor E. of Henstone Band, at the head of Gate-up Gill. There I found buried in the peat, Hazel nuts, many of which were bored by a maggot, proving that the nut came to maturity, and that the kernel was eaten out by the moth before, in its immature state, it ate its way through the shell.

There are many Oaks in the peat bogs between Blayshaw Gill and Brown Rigg, 1000 to 1250 feet; and a very large Oak, 30 feet long, was dug up at Biggin Grange, Kexmoor (550 feet). In Sykes Moss most of the buried trees are Oaks, Sealhs, and Birks. The Birk is easily recognised by its bark, and an old Sealh is known by its red wood,—the wood of the young Sealh is white. The stumps of the Birch are often preserved erect, but sometimes, though apparently solid, they are so rotten as to fall to powder at the touch.

If we except Woo Gill, the present general limit of the Birch cannot be placed higher than 1100 feet, which gives a *general* lowering of the Birch limit of some 500 feet during the formation of the peat. Taking the Oak at 950 feet, the lowering is 300 feet. The Hazel at its extreme limit, 1350 feet, gives a minimum lowering of 300 feet, but the general lowering is much more than

that. From the remains of the lost forest, we can distinguish two zones, that of Oaks, up to about 1200 feet; and that of Birks, above that level. No doubt there would be no difficulty in constructing a fairly good map of their ancient distribution, if one had time to devote to it.

The peat on the moors, which has engulfed the ancient forest, does not here run to a great thickness; a large number of observations proving a limit of 6 to 8 feet. It would not, therefore, require an incredible time for its formation. It is not now forming, but is undergoing a process of destruction. Except in the 'Whams,' the conditions for its formation do not exist. In summer the peat becomes very dry and dusty, and is blown away; whole acres together of bare rock, S.E. of Great Whernside having been thus denuded.

We now come to consider whether there is any evidence as to how recently the forests extended much above their present limits on to the moors. The word "With" is common in the sense of "Wood," and as the name of numerous woods and so of places. It does not occur in Nidderdale, however, above Hartwith, but in Washburndale, "Blaywith Wham," *i.e.*, "Bleak Wood Swamp," is over 1000 feet, and on a southern slope on the open moors. There are no trees there now, nor are there any at Grimwith, similarly placed on the Wharfedale side of Greenhow Hill. As the word is Old Norsk (*vidr* a wood), this raises the curious question, 'Were there any trees there when the Danes settled in this part?' Some light may be thrown upon the answer by the parallel case of "Shaw," a word also meaning a "wood;" a word also exclusively Danish in this sense—(O. N. Skógr; Swed., Skog; Dan., Skov.) The analogous words A. G. Scúa, O. N. Skuggi, Dut. Schawe, mean simply 'shade,' 'shelter.' 'Shaw,' common enough to day in the sense of 'wood,' occurs in the same sense in Chaucer and the Old Ballads. Thus—

> "Gaillard he was as goldfinch in the shawe."—
> CHAUCER.—*The Cook's Tale.*

And the beautiful lines in "Robin Hood"—

> "In somer when the shawes be sheen,
> And leves be large and lang."

leave nothing wanting to prove this.

'Shaws' are frequent on the moors far above the present limit of tree-vegetation These Shaws are generally boggy ground, sheltered or associated with crags or rocky places. Thus there are no trees on "Feather Shaw," 1250 feet; "West Shaw," 1200 feet; "Foulshaw Crags," 1000 feet; and many others. At present when a great elevation is attained by the stragglers, they are always found at the base of a bed of grit or sandstone, from which there is a perennial ooze or spring. These are just the places where the last vestiges of the ancient forests at these elevations would be preserved, and I do not hesitate to affirm my own belief, that they were in existence long since the coming of the Danes, and that a lowering of some hundreds of feet has taken place in the forest line within the last thousand years.

ON THE SECTIONS OF THE DRIFT OBTAINED BY THE NEW DRAINAGE WORKS, AT DRIFFIELD. BY J. R. MORTIMER.

THE sections of the Driffield drains, to which I now beg to call attention, speak much for themselves; however I deem it necessary to give a few explanations, and to express my views on certain features having a close relation to the beds shown in the sections. These sections were obtained in the year 1879, from personal observations made twice, and occasionally three times, daily during the excavation of the drains, and from notes kindly given me by Dr. Wood, of Driffield.

The drains run in the main nearly N. and S., E. and W.; they embrace an area of nearly 40 acres, and in section give a total length of about 6 miles. They average a depth of about 8 ft.

A glance at the sections shows the frequent interbedding of thin patches of a sandy nature; and the peculiarly complicated manner in which masses of almost pure chalk-gravel of every form and size, are pushed into and deposited on the clays. No two parallel sections, if even but a few yards apart, would show the same appearance in the arrangement of the beds.

The clays consist of the feather edges of what are known as the "purple clay," and the brown "Hessle clay," of Messrs. Wood and Rome, which are frequently so intricately dove-tailed and squeezed together as to have obliterated every well marked line of separation. On the other hand, on the Nafferton road and in a few other well marked places, hardly anything but brown "Hessle clay" was exposed, which in places seemed to overlap the edge of the "purple clay."

The two clays contained boulders which are, in the main, more or less rounded, very variable in size and derived from many different kinds of rock. They are frequently polished and finely striated. Yet not infrequently they are found with their angles and edges as sharp as if quite recently detached from their parent beds. In a few instances unbroken pieces of rock, showing lines of bedding and cross fractures, but still held together in a connected mass, have been safely carried and dropped in the clays and gravels, as at "A," in Westgate.

The gravels consist almost entirely of more or less water-worn pieces of chalk of small size, with occasional boulders of travelled rock, chiefly water-worn and very variable in size. Many of the small patches of pure chalk gravel enclosed in the clays, are true boulders, having been conveyed in a frozen condition, or in pockets in the ice, which carried and dropped them into the clays. This view is supported by the fact that much of the gravel is found standing on end. Large foreign boulders are not infrequently found in the gravel, as well as in the clays, standing on, or nearly on their ends, and sometimes on their small ends.

The peculiar dovetailing of the chalk-gravel with the clays, and the clays with the gravel, observed in these sections, is mainly confined to a limited zone along the inner edge of the chalk range, from the sea to the Humber. It is well shown on the coast between Bridlington and Danes Dike; and has formed the subject of interesting papers by Mr. Dakyns, of the Geological Survey, and Mr. Lamplough, of Bridlington.* The eastward extension of the dovetailing of the chalk-gravel *with* the *clays* appears to be, as far as can be observed on the surface, due to a string or chain of sand, gravel, and clay ridges and mounds. These ridges are mostly arranged with their longest axes parallel with the inner edge of the chalk hills, and often merge, or nearly so into one another at their base, forming a barrier-ridge at a distance varying from about one mile near Bridlington, to nearly five miles opposite Hull, from the inner edge of the chalk wolds; thus preventing to a great extent, the eastward flow of *gravel-loaded* bergs from the eastern edge of the land ice, capping the chalk hills.

The Poundsworth ridge in the neighbourhood of Driffield, consists of 12 ft. of brown boulder clay, under which is 24 ft. of finely laminated *marl clay* running towards the bottom into clay marl and resting on chalk. These mounds are not moraines, but seem to have been in the main conveyed by masses of floating ice, broken probably from an ice-sheet traversing the North Sea, and loaded in part with Scandinavian and Danish rocks.

Embedded in the beach near Easington, there is a large mass of chalk, with its bedding and lines of *black* flint, unbroken and dipping slightly to the east. I am certain it is not part of the Yorkshire chalk by the character of its flint; but as far as I can judge it is identical with that of Denmark. Also in the *southern* portion of the cliffs, between Hornsea and Spurn, foreign flints seem to preponderate. A little north of Hornsea the clays contain a large proportion of Yorkshire chalk flint, and bits of red

* Proceedings of the Yorks. Geol. and Polytc. Society, vol. vii, pages 242 and 246.

chalk, and the chalk-gravel capping the cliffs contains hardly any but Yorkshire flint. Also in the clays below, even to the base of the cliffs, are transported masses of crushed and redeposited chalk, very variable in size ; but *unlike* the transported chalk near Easington, they contain no foreign flint.

Most probably the chalk gravels and masses of crushed chalk between Bridlington and Hornsea have been derived from the neighbourhood of Flambro' Head, having been removed and carried to the place they now occupy, by the stream of bergs from the northern ice sheet shearing against the Head. These ice rafts, after ploughing the bed of the ocean and pushing clayey matter before them, probably became fixed, and on the melting of the ice, the transported matter was dropped in patches and pockets of every shape and size ; being more or less rearranged by the ebb and flow of the tides, into every form of false bedding, as is so beautifully shown in Craike Hill, and many other similar mounds and ridges dotted throughout Holderness. The rebedding observed in these ridges, the 24 ft. of laminated marl clay under 12 ft. of boulder clay in the Poundsworth railway cutting, and the thin intercalated beds of a sandy nature, shown in the accompanying sections, may be due to a somewhat mild interglacial period. This would seem to be indicated by the unstratified boulder clay, which has been observed to cap Craike Hill, and also to cover Kelsey Hill and several others of large size throughout Holderness, and which must have required very different conditions for its formation.

To avoid any necessity for a great change in the climate, and also a change in the relative height of land and sea at that time, we may suppose that the laminated marl and the thin patches of a sandy nature were formed and intercalated with the clays, by having been, in most cases, deposited in areas of still water enclosed between stranded ice rafts. Lakes of various sizes might have been thus formed ; and frequently little pools would exist in the dissolving bergs themselves, *Afterwards* other rock burdened rafts in

Fig. 1.

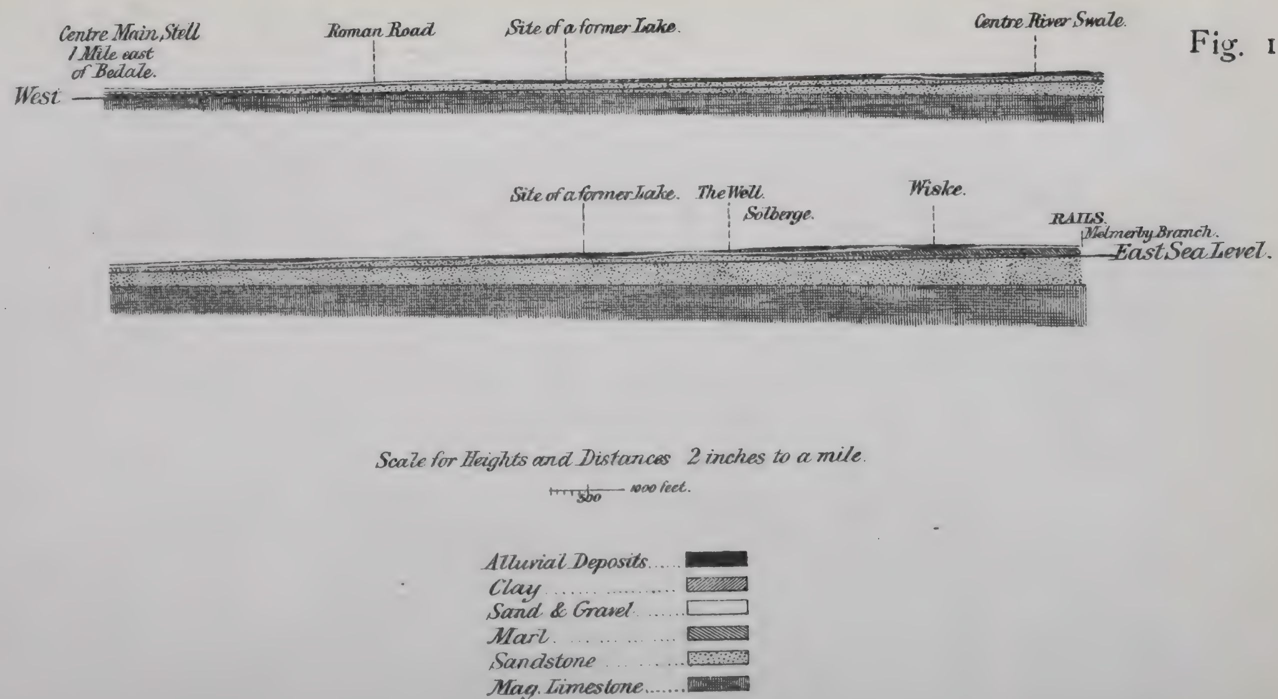
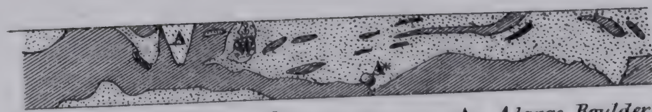

Centre Main, Stell
1 Mile east
of Bedale.
West
Roman Road
Site of a former Lake.
Centre River Swale.
Site of a former Lake.
The Well.
Solberge.
Wiske.
RAILS.
Melmerby Branch.
East Sea Level.
Scale for Heights and Distances 2 inches to a mile.
500
1000 feet.
Alluvial Deposits
Clay
Sand & Gravel
Marl
Sandstone
Mag. Limestone

Fig. 2,



A. Filled Trench. "W. Sandy Clay. A* A large Boulder.

Harland Lane.

Fig. 3.

D. Sharp Sand like Sea Sand.

Washington Street.

Boulder Clay ....
Chalk Gravel ....
Patches of Sand ......

passing over might drop boulder clay and cover the patches of sand and laminated marl as we now find them.

These sand, gravel, and clay mounds distributed over most of Holderness in great numbers, denote then the frequent grounding of rock-loaded masses of floating ice. Their north-western limit seems to have been determined by the approach of shallow water, on nearing the edge of the chalk hills; there they came in contact with the edge of the land ice which capping the chalk hills and pressing eastwards down the dip slope to the sea, crushing and grinding the chalk into the form of gravel, and on the inner margin of the wolds, much obliterating the hills and dales. To these opposing forces—land ice and bergs—I attribute all the peculiarities of deposition observed in the sections, as well as the transport of foreign material. The edges of the land ice-cap would break off into pieces on reaching the shore line and soon become stranded, or for a time float hither and thither, as they melted dropping their loads of chalk gravel into the hollows of the clay which had been ploughed up by the sea-borne bergs.

But as before stated, the land-borne chalk gravel is mainly confined to an area included between the inner edge of the chalk hills, and a line of sand, gravel, and clay mounds and ridges, formed by the packing and stranding of icebergs, which had checked, except in a few cases, the flow of land-ice eastwards. Hence the less frequent occurrence of chalk gravel in the interior of Holderness, until the present coast-line is reached, where it is seen in lenticular sheets at the top of the cliffs. Probably it has for the most part been brought from the promontory of Flamborough head. It is worthy of note that this line of mounds and ridges is, in the neighbourhood of Hull, as previously mentioned, much further from the edge of the chalk hills than it is towards Beverley, Driffield, and Bridlington. This may have been caused by a western flow of ice through the gorge of the Humber, accompanied by an under current of water, which would keep back in its front, the bergs from the Scandinavian ice-sheet. And it is very probable

that this gorge itself was considerably widened, and possibly in part excavated through the upper beds of the outcropping chalk, by the pressure eastwards, during the height of the great glaciation. Possibly this was the narrowest and weakest place in the whole ridge of outcrop between Flamborough Head and the Wash. That at one time all the water did not pass through the present channel seems to be proved by the two or three sections shown in the face of the large chalk pit near Hessle Station, 40 to 50 ft. above the present bed of the Humber, which I take to be old river beds filled with drift. Besides we have proof that large masses of the upper beds of the chalk have, in places, been crushed and bodily removed by the great pressure of land-ice.

At Driffield, the main drain exposed a large mass of this crushed and displaced chalk, extending from the river head to the Albion flour mill. Part of this mass can now be seen in the bed of the stream : and in other parts of Driffield, disturbed chalk was observed, as shewn in the sections. A little to the north-east of Wharram Station, on the brow of the hill, close by the side of the road to the village of Wharram, is a pit showing nothing but crushed chalk. And at Hutton Cranswick, three miles south of Driffield, is a large outstanding boss of chalk, the upper beds of which, to a depth of about 12 ft,, and over a considerable area, are much shaken, and seem to have been displaced. In one of the Hutton sections, the upper portion of the disturbed chalk contained, the last time I saw it, two drum-shaped pockets of sharp sand and small gravel completely enclosed in disturbed chalk. Numerous other instances of removed chalk could be given, and probably a close examination made in the neighbourhood of the Humber gorge, would discover traces of crushed chalk, indicating great displacement from the sides of the gorge. This grinding and displacing action of the ice I believe to have been confined mainly to the inner portion of the chalk hills, and to the sides of the valleys having a free and easy opening into the sea.

The intricate ramification of the dales, completely filled up

with ice, (except where there was a free and lengthy flow into the sea) would be such as to convert hill and dale into one firmly knit mass of immoveable ice to a level with the summits of the hills. Over this compact mass, the upper portion of the land-ice would slide eastwards; at first comparatively *slowly over the outer ridge* of the chalk hills, but with *increased* velocity and effect on their inner slope, and would grind down, or push before it, all outstanding peaks of chalk; hence arise the displaced masses of rock and the great accumulation of small chalk gravel at the inner edge of the wolds. This shearing tendency of the upper portion of the ice-caps, would be *not to* excavate, or *even to deepen* the then existing dales, but to plane down the tops of the hills, and press small gravel into the cracks and rents in the ice filling the dales, which gravel would slowly sink, and in great part finally reach the bottom of the valleys where we often find it.

Some of the main dales, such as the one terminating in "Garton Slack," and the great Mid-wold valley, which runs from Wharram-le-street, with little interruption, to Bridlington, having free and somewhat straight courses in an easterly and south-easterly direction into the glacial sea, have had their sides rounded and worn back, and their bottoms raised by part of the material removed from their sides by the moving ice. (I know of no proof that ice ever deepened the chalk dales of Yorkshire.) At the same time, the steep narrow-bottomed valleys which occur almost everywhere along the outer side of the wolds, were securely sealed with motionless ice, as before pointed out, so that their sharp outlines were protected and preserved for a long time from every kind of of denudation.

Besides the preservation of the dales, this capping of ice may probably assist us in explaining another interesting and very puzzling feature, with regard to the irregular distribution of glacial drift on the high parts of the wolds. It *is only at the eastern extremity* of the chalk along the cliffs from Sewerby to Speeton, and to the extent of about one mile inland, that the boulder clays

and other drift deposits are found to almost completely fill up the old preglacial chalk valleys, and in the form of a ridge near the latter place to cap the summit of the wolds up to an elevation of 400 ft., with a thickness of from 50 to 60 ft. In no other place, along the whole length of the elevated outcrop from Speeton to the Humber, do I know of any trace of a valley having ever been completely filled up with drift, in the same manner as those in the neighbourhood of Flamboro'. All we find is a few small patches of sand and gravel, and occasionally clay, of a somewhat doubtful age, in shallow depressions on the summits of the hills, but rarely in the bottoms of the valleys. Had the valleys on this large area of the wolds ever contained the drift to the extent it is now found at Flamboro' and Speeton, we should, I think, find numerous traces of it. It is difficult to conceive how it could have been swept so completely from the whole of the valleys, except in the above named small area along the coast, where to all appearance its removal would have been equally easy. The great probability is, that where little or no trace of the drift is now found on the chalk area, very little ever existed. The fact that the preglacial valleys are filled in, and the hills capped with boulder clay along the east coast to an extent of one mile inland only, seems to mark in this neighbourhood, the western limits of the Scandinavian and northern ice-sheets, which pushed before them great quantities of earthy matter plowed from the bed of the North Sea, and rode over the chalk area until arrested by the land-ice, which had already filled the valleys and capped the hills, and was creeping eastwards.

This capping of land-ice would seal up the dales, and even if submerged for a time, would only admit drifted material to reach the chalk through rents and breaks in its mass, hence the almost entire absence now of boulder clay, and the comparatively small quantity of transported sand and gravel. I repeat that the sharp outlines of many of the dales are mainly due to having been thus preserved by this lower stratum of ice.

After the disappearance of the ice, the last touch given to the

configuration of Holderness and the edge of the wold hills would be given by the waves of the retiring sea. Meteoric influences have since then done comparatively little.

ON FLOTS. BY J. R. DAKYNS, M.A., OF H.M. GEOLOGICAL SURVEY ENGLAND AND WALES.

THE word "Flot" may be briefly described as a miners term for ore lying between the beds, or at certain definite horizons in the strata.

As very little is said about Flots in manuals of Geology, it is to be presumed that not much is known about them to Geologists: under these circumstances every little helps, and I propose to contribute my mite towards a better knowledge of the subject.

In books, the term used is generally flat or flatting, as if to indicate ore lying flat instead of vertically, but it is to my mind extremely doubtful whether the term Flot, which is the only form of the word I have ever heard used by miners in this connection, is really equivalent to flat: at all events the term is used where the flot or the bedding plane in connection with which the ore is found, is anything but flat, but often inclines at a high angle. I think the word is most likely of German origin, as so many mining terms are. Nor do the miners who talk of flots, so pronounce the ordinary word flat, as far as I am aware.

The flots with which I am acquainted are of two kinds, distinct yet allied. 1st. Flots connected with "cross veins" 2nd. Flots connected with courses of Dun Limestone. I will describe them in order.

1st. Flots connected with "cross veins."—To describe these I must first explain the term "cross vein." In the country where these occur, viz., the neighbourhood of Greenhow Hill, the ordinary lead-bearing veins are generally E. and W. veins; using

the term E. and W. with some latitude, as is usual in such subjects, these E. and W. lead veins are crossed by others of a N. and S. trend, which are on this account called "cross veins." These cross veins do not as a rule yield ore, they are mostly mere spar veins, and when they do yield ore, it is at the intersection of an E. and W. vein for the most part. On the other hand, the E. and W. veins sometimes stop off against a cross vein. They are also sometimes, perhaps generally, shifted, " or thrown' as the term is, by the cross veins, *i.e.*, if you follow an E. and W'. vein having a certain general direction or "random" till you come to a cross vein, a corresponding vein of the same general random will be found to start some distance to the north or south on the other side of the cross vein.

Now at Grimwith Moor, adjoining the ore. wherein the kind of veins described above occur, but composed of the same rocks, viz., Carboniferous Limestone, lead ore is found not in veins but in flots. I have already said that this term indicates ore lying between the beds ; but it must not be supposed that such ore runs to any great distance along a bedding plane as a coal-seam does. The mode of occurrence is this :—The flot planes only bear lead, where a spar vein, one of the cross veins mentioned above, intersects it. So much for the first kind of flot.

2nd. Flots in connection with courses of Dun Limestone.—In the Buckden, Gavle, and Bishopdale district, the mode of occurrence of this kind of flot is rather different from that described above. The ore has been hereto developed in certain definite planes or at certain definite horizons only, and not everywhere along this horizon, but only at the intersection of other and cross courses ; but in these cases it is not so much at the crossing of a spar vein, as at that of a course of Dun Limestone. Dun Limestone is a dolomitized limestone, and is called Dun from its brown colour. In this country the ordinary limestone, Yoredale or Carboniferous, appears to have been dolomitized sometimes in beds, sometimes in great irregular masses ; but more generally in ver-

tical or approximately vertical courses having a general parallel trend of N.N.W., or nearly magnetic north and south. These Dun courses, or streaks as they are also called, are *the* important features in the flot district. The miners always look out for lead where they find a dun course. These dun courses bear a precisely similar relation to the flots that the cross veins above described do. There is this difference, however, a cross vein is a comparatively narrow crack in which ore is found at the flot planes. Dun courses are sometimes several fathoms wide. Where a dun course crosses a flot plane, the metal is found up and down *between* the dun and the white limestone.

GLACIAL SECTIONS NEAR BRIDLINGTON. BY G. W, LAMPLUGH.

In the neighbourhood of the seaport towns on the east coast of Yorkshire, the continuity of the cliff-section is now nearly always broken by artificial works, raised sometimes for one purpose, sometimes for another, but always with results equally fatal to geological interests. The gaps thus made, have a constant tendency to widen as the towns spread along the cliff-tops after the fashion of watering-places; so that the inconvenience arising to geologists from this cause will become more and more evident. Already there are cases in which the sections thus hidden have been sorely needed, as for instance, at Bridlington; where the shelly deposit in the boulder-clay to which the name of "Bridlington Crag" was given, was covered shortly after its discovery by a strong sea wall. It was so completely screened from observation, that when, some time after, the Drift deposits of the coast were examined and divided, the actual position of this bed in the series had become a matter of theory, and, as the open cliff on either side of the town showed only 'Purple' boulder-clay, with nothing to indicate the presence of any lower division in the neigh-

bourhood, the deposit was naturally described as occurring in the 'Purple Boulder Clay.'*

But, by the discovery of a lower division—the 'Basement' Clay of Messrs. Wood and Rome—on the beach near the town, a little below the cliff-line, Mr. Bedwell and myself were able three years ago to prove pretty conclusively that the shelly bed really had its place in the 'Basement' Clay, and not in the 'Purple.'† Since then, occasional breaches in the sea-walls and other accidental sections have shown that such is undoubtedly the case; and that, curiously enough, the 'Basement' Clay rises into the cliff to the south of the town just where the sea-defences begin, and sinks again to the beach, only a few hundred feet from their northern termination, making a substantial show in the cliff between these points.

There is also another cause of geological destruction on this coast, which, though working perhaps in a manner not quite so obtrusive, is even still more fatal to the sections. I refer to the work of that swallower of sections, the sea, which cuts and pares through the drift cliffs unceasingly, turning over section after section like the leaves of a book; and when once past they are gone for ever—we cannot turn back. And the series of ever-changing pictures of these variable beds which is thus presented to us, is of no common interest, and would yield, could we but note them for long enough, a section in any direction. In many parts of the cliffs it is easy to see that in a few years' time the section will be very greatly altered, and the old one gone beyond recall. Thus is the sea ever changing our old pictures for new ones.

Then again, on the sandy and pebbly beaches the restless work of the sea in now and again stripping off, for a time, the shingly covering which usually hides the beds, is often of great importance to the geologist, for it is wonderful in how many cases

* Messrs Wood and Rome. Quart. Jour. Geol. Soc. vol, xxiv, p. 149.

† Notes on the Bridlington Crag and Boulder Clay. Geol. Mag., Nov., 1878.

GLACIAL SECTIONS NEAR BRIDLINGTON. *PART 1.*

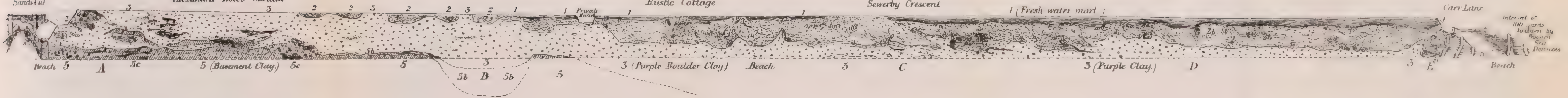
Proc. York. Geol. and Polyt. Soc., N. S. Vol. VII, Pl. XIX

Section Nº 1. Cliff between Sands Cut and Carr Lane (opposite the Alexandra Hotel,)

Now hidden, except 8 feet at the top, behind the new Sea Wall.

Scale,_ 60 feet to an inch.

Feb. 1881.



Section Nº 2. Cliff, from end of Wooden Sea Defences 100 yards north of Carr Lane to Sands Lane.

(Section undergoing constant change owing to rapid inroads of the Sea.

Scale as above

May 1881

Enlarged Sections

Scale_ 10 feet to an inch.

1 Enlargement of part of the Section below the marl at D to show position of fresh water remains in gravel

Feb 25, 1881

2b. Sand, with lumps of Sandy Clay containing Limnæa Peregra in abundance.

2 Thin layer of Sandy Clay like that in the fold but contains no Shells.

2. Section shown in excavating back into the cliff for the northern end of the Wall

Oct. 1881

2b Clayey Gravel and Silt with patches of Peat tilted on end and unconformable to 2

XX Doubtful streaks of Marly Clay with a few shells

3 Enlargement of Section in Gravel near C, seen during the building of the wall to illustrate contortions and intrusion of Boulder Clay

April 13, 1881

NOTE The capitals indicate points referred to in the description. The dotted lines below the cliff line show the course of the beds on the beach

Explanation.

1 Fresh water Marl.
2 and 2a Drift Gravel and Sand.
2b. Fresh-water remains in Gravels.
3, 3a and 3b Purple Boulder Clay
4. Laminated Clay.
4b. Sand above Laminated Clay.
4c. Earthy Chalk wash below Laminated Clay (only seen on beach here.)
5. Basement Boulder Clay
5b Dark muddy Sand with Pebbles (re arrangement of Boulder Clay)
5c Included masses of Sand and Clay, generally with Shells

A. Nagros Lith. Leeds

the chief interest of a coast-section lies between the tide-marks.

The engineer, like the sea, often compensates for the loss of one section by the gift of another, in the many works he undertakes; and his gifts like the others are generally soon withdrawn

Now, though in many cases these occasional sections may appear to us of no great value, it seems to me that we should always take advantage of the opportunity; for we cannot foretell their future importance, nor foresee how great may one day be the need of them, the mere fact that a section does contain nothing of importance may at sometime be of the greatest service.

Under these considerations I have resolved to note—as seems to me the duty of a local geologist—whenever the opportunity occurs, any section in the neighbourhood which is likely to be destroyed, either by artificial or natural means—making a careful sketch if the beds seem complicated or unusual, and in all cases giving as clear and unbiassed a description as I can, adding afterwards any personal notes and inferences which are likely to be of use—so that any future geologist, who may be interested in the locality, may have something more satisfactory than "the marks of that which once hath been"—a brick wall perchance, or a filled-in drain—to work upon.

Nor could I have chosen a better time to begin than the present for there have just been, and are now, sections uncovered which in a few months will be hidden for an altogether indefinite period. No sooner had one line of wrecked sea defences been completely renovated—during the course of which the section accompanying this paper was laid open—than the sea has broken through another series directly to the south, and threatens at the time of writing, unless speedy measures be taken, (of which there is no immediate likelihood) to sweep away the whole. Besides this, the town is now being deeply drained, and a series of sections may be collected which will probably throw light on the remarkable differences between the beds on the north and those on the south side of the town.

I should also like to include in the series some account of various exposures of the Neocomian Clays and accompanying strata on the beach at Speeton which I have examined, and which might add to the knowledge of those beds.

Some of the sections I shall describe have a present value; others may be only of future importance; but all, I hope, will be found useful when the closer and more searching elucidation of our Yorkshire drifts—without which the task of correlating them with those elsewhere is full of difficulty and doubt—shall be attempted.

SECTION NO. 1.—*The Cliff Section now hidden behind the new sea wall opposite the Alexandra Hotel.*

SECTION NO. 2.—*The Cliff Section from the end of the defences,* 100 *yards north of No.* 1 *to Sands Lane; undergoing constant change owing to rapid inroads of the sea.*

Introduction.—Section No. 1 had long been hidden by wooden defences, but these having been broken through in several places, partly by the slipping cliff behind, partly by the stormy sea in front, were removed by the local authorities in the autumn of 1880, and were replaced last spring by a more substantial concrete wall; which now again hides the whole section, except about eight feet at the top. During the interval between the removal of the old defences and the erection of the new, there occurred a stormy period, during which the slips and rubbish that obscured the section were almost entirely removed and the cliff-line laid clean and bare. During the progress of the works almost every foot of the section was made clear,* and the result thus obtained is represented on a natural scale in Fig. 1. It extends from the road to the beach known as 'Sands Cut,' northward† to

* Both this and the following section have been worked in bit by bit, as the different parts became clear. At no one time was the whole so clear as here shown.

† I have throughout described the beds from south to north, so that words signifying direction or distance refer northward unless otherwise stated.

'Carr Lane,' a distance of about 1,000 feet. The average height of the cliff is about 30 feet.

Intimately connected with this part of the cliff is the section No. 2, which is indeed the northward continuation of it—the interval between them, only about 100 yards, being hidden behind strong low defences which are not likely to break down. I know of no part of these cliffs which suffers such rapid disintegration as does this short section; the incoherent nature of the beds, the soft destructible character of its base, combined with the increased scour of the waves caused by the protections on either side, resulting in a destruction so rapid that in a few years the section will probably be completely changed, unless artificially protected* The ground slopes inland and forms the eastern edge of the extensive but irregular hollow which held the shallow lake whose relics remain in the freshwater marls of these sections, and whose extent and conditions is being admirably laid open by the drainage works in the town; and, unless prevented the sea will before very long eat still further back into the lake hollow, when the whole section will probably resemble the southern end of it as now seen.

Synopsis of Beds.—The following is an abstract of the beds which these sections exhibit:—

1. Banded freshwater marl, containing many shells and traces of plants.

2 and 2*a*. Drift Gravels containing a large proportion of chalk.

3. Dark purple boulder clay, (the 'Purple Boulder Clay') which in section No. 2 splits (3*a*† and 3*b*) and admits a gravel. (2*a*.)

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* For the changes which this section has undergone in a short period, compare it as now given with a rough sketch of it illustrating my paper in the Geol. Mag., Sept., 1879, and with Mr. Dakyns' drawing, Proc. Yorks. Geol, Soc., 1879.

† Although I have here included the upper band of Boulder Clay of section 2 (3*a*) as Purple Boulder Clay, it is by no means certain that this may not eventually prove to represent the later Boulder Clay, named by Messrs. Wood and Rome the 'Hessle Clay.' In fact, throughout I have only used the present terminology provisionally, and until, with a fuller knowledge of the beds, a more perfect division with more certain terms shall have been suggested and adopted.

4. Finely laminated chocolate-coloured clay, entirely free from stones. This only occurs in detached and crumpled patches in section No. 1, but is seen in place and almost undisturbed in section No. 2, where it has above it *a thin seam of sand, (4b)* and below an inconstant layer of *earthy chalk wash. (4c.)*

5. Dark greenish-blue Boulder Clay (the Basement Clay): more sandy than the Purple Clay, and of a patchy streaky nature: includes masses of fine clay and mingled sand and clay, often containing arctic shells, generally crushed (5*c*, the 'Bridlington Crag): has above it in places a sandy silt with pebbles, 5*b*. (probably a rearrangement or wash from its surface.) This division is only seen in section No. 1, but it is present on the beach opposite No. 2.

Detailed description. Section No. 1 slopes gradually from south to north; forming the southern side of a hollow which reaches its lowest level just beyond the section. Section 2 forms the north slope of this hollow.

The Fresh-water Marls (1) occupy and partially obliterate this hollow, coming in at about the same level on either side, at first very thin and interrupted; but thickening rapidly as the cliff sinks, they attain a maximum of about 7 feet near the middle of the depression. They consist of a very fine, tenacious, elastic mud, arranged in bands varying in colour from a dirty white to a deep bluish-black. They contain many fresh-water shells of existing species and roots and other traces of plants, and at one time showed in their midst where thickest, a thin band of peat with wing-cases of beetles and small seeds, but this has disappeared as the cliff has wasted back. They rest unconformably on an uneven and eroded surface of contorted gravel, filling up many unequalities thereof. In places there is a few inches of rearranged gravel immediately below the marls and conformable to them.

The Gravels (2) on which these marls rest, show throughout signs of great disturbance, being strangely contorted and crushed—often compressed into vertical folds *(see enlarged section 3)* and often ending abruptly against boulder-clay *(between C and D of*

section No. 1*)*, or against tilted masses of gravel *(enlarged sections* 1 *and* 3*)*. The bedding however, which is well brought out by seams of sand and layers of sandy clay, is not often completely lost. The gravel consists in great part of chalk pebbles, not very completely rounded. These pebbles being stained by water from the marls above, give a decided, and in places very deep, iron-red look to the mass. Drift pebbles occur throughout in varying proportion, and I have noticed a few large boulders in the lower part.

I have found fresh-water remains in the gravels at one or two points of the section, notably at D and E. These consisted of shreds of sandy clay with shells of one species—*Limnœa peregra*—at D; and at E, and one or two other points, of black silty mud, with vegetable—chiefly mossy—remains. These at E seemed to be connected with patches of an older gravel; but in a section so disturbed as this, it was somewhat difficult to tell whether these remains were shreds torn from a lower bed, or were in place, and evidence of fresh-water conditions. To this point I shall revert in the concluding notes. The mode of occurrence of these remains is shown in the enlarged sections Nos. 1 and 2.

The junction of the gravel with the boulder-clay is most irregular and peculiar, the clay protruding in long tapering masses far into the gravel in every direction and at every angle, and assuming many curious shapes: throwing off also detached bosses (though these may in many cases be really sections across protrusions); presenting often steep-sided hollows filled with gravel, with interlocking arms of clay *(between C and D, section* 1*);* and thus giving rise to the fantastic outline shown in the section.

The gravel (2*a*) which divides the Purple Boulder-clay in section No. 2, very closely resembles the upper gravel; it contains, perhaps, a little larger proportion of sand, and has been shielded by the overlying clay from the irony tinge derived from the marls; but otherwise there is no difference between them in appearance. This second gravel is evenly bedded, and shows

very few signs of disturbance. It contains a few very small fragments of marine shells—such only as might have been derived like the drift pebbles from the washings of a boulder clay.

The Purple Boulder Clay (3) is a hard, tough boulder clay of dark brownish-purple colour* ; contains more boulders than the Basement Clay and they are generally larger ; has an occasional marine shell fragment, worn and sometimes scratched, and probably a mere pebble. The disturbance of its upper part has already been touched upon ; the sides of the steep hollow between C and D in section 1 showed slickensides, and their bases were grooved into deep steps. The protruding masses also in some cases exhibited the same signs of movement, and some detached patches of laminated clay included in its base near A showed similar symptoms. Indeed, throughout section 1 this clay seems to have been disturbed to a great depth; near C the upper eight feet appeared to have slid over the dome shaped masses below, and the top of it was arranged in thick plates which did not look like bedding. At the southern end of the section there is great confusion ; isolated patches of gravel and sand, probably of two or three ages ; of laminated clay ; and of the Basement Clay, were all mingled with the Purple Clay in a manner far too intricate to be faithfully rendered on a small scale.

In section No. 2, a little distance beyond Sands Cottage the Purple Clay divides and admits the gravel 2*a*, as has already been described. The upper band, 3*a*, has suffered severe erosion, and is cut and dragged much in the same way as the top of the clay in No. 1, but not on so large a scale. In one or two places it is broken quite through, and then the red tinge of the upper gravel spreads into the lower. I have already referred to the doubt as to whether this upper band may not represent the newer

* The attempt to describe in words the mixed indefinite tints of such beds as these is very futile. In most cases the description fails to convey any clear impression to the reader unacquainted with the bed, or gives him an erroneous idea. They are only of use as comparing one bed with another.

'Hessle Clay' of Messrs. Wood and Rome, which, it will be noticed, is not otherwise seen in these sections. I do not purpose entering into this question on this occasion, as the drainage works now being carried on in the town will yield fuller evidence on this point.

The lower division of the clay (3*b*) is undisturbed *and seems to pass downwards into sand*; at any rate, there is a few inches of what looks to me like finely-bedded clay—different from the flaky look of the top at *C* in *section* 1—between true unstratified boulder-clay and the seam of sand which overlies the laminated clay.

This division in the Purple Clay and the intermediate gravel—which however completely changes its character—may be traced with difficulty as the cliff is much obscured with talus, for about a mile northward, to the beginning of the chalk. Beyond that, though the division seems to be continuous, the mediate beds are very intermittent. In going northward from section 2, the cliff rises suddenly *(Potter's Hill)*; and beyond, the upper gravel, which swells out to a thickness of 8 to 16 feet is evenly bedded and overlies the upper clay band, (also greatly increased in thickness) with very little irregularity for over a mile, when the top of the clay is again somewhat deranged. It has been suggested that this thick and regular gravel—the 'Sewerby Gravel'—may be of different age from the low level gravel of these sections, and that this may be a re-arranged valley gravel. On this point the evidence is not conclusive.

South of the point where the middle gravel (2*a*) begins, there is, for a short distance, a series of lines in the boulder clay; and these, as they occasionally contain a few leaves of laminated clay, seem to be bedding planes.

The Laminated Clay (4), the next member of the series, exists in Section No. 1 only in detached patches in the base of the Purple Clay near A; but in Section No. 2 it forms the base of the cliff and reaches some way down the beach, having a thickness of about 8 feet. Above it, there is an intermittent seam of fine

clean sand (4*a*), and below it, a curious bed of earthy rubble full of very small chalk pebbles, looking like a surface wash (4*b*). But as I have already described these beds in the "Geological Magazine" for Sept., 1879, I need not here enter into further particulars.

The Basement Clay (5), of section No. 1, with its included masses of clay and sand with arctic shells (5*b*) forming what has long been known as the 'Bridlington Crag,' is of great interest, and I have made it the subject of a separate communication, which was read at the British Association Meeting, at York, last September, and has been printed in the "Geological Magazine." for Dec., 1881. It is therefore needless here again to describe it.

I may however mention the occurrence above the Basement Clay, just before its disappearance in section 1, of what looked like a re-arranged wash from its surface, in the form of a dark silty mud with pebbles and worn shells (derived from the clay?), which gave out a fœtid odour, and appeared to me rather of fresh-water origin than marine. This silt filled a very sudden and deep hollow in the Basement Clay at B to a depth of about 16 feet, and caused much trouble during the building of the sea-wall, as no foundation could be got in it; it was in the end bridged over. It is probably of the same age as the earthy rubble below the laminated clay in the Section No. 2, (*b*), already referred to; indeed it is possibly the continuation of it.

Such is as faithful an account as I can give of these two interesting sections; and there remains only to add such inferences that I have drawn from them as may seem worthy of record; either as showing what were the impressions given to an observer, or as indicating the standpoint from which I may have described the beds.

Notes and Inferences. The most striking feature of these sections is the fantastic contour of the line between the Purple Clay and the gravel; and I have carefully sought for any clue which might help me to comprehend the method of its formation,

but my present knowledge of the action and effects of the different eroding agencies is far too slight to lead me to any safe conclusion on the subject. A few suggestions and speculations, however, have occurred to me, and may be taken for what they are worth, thus :—

The upper clay-band in section No. 2 has evidently suffered severely from erosion, for only a few hundred yards further north it has a thickness of 10 feet, whilst here it is in one or two places quite cut through. Now where it is continuous, there is a well marked difference in colour between the gravel above and that below it, and this is the only distinction between them. But where the gaps occur and the gravels come together, the red stain of the upper gravel diffuses itself into the lower, and it is very difficult to say where the one ends and the other begins. And it seems very probable to me, that in section No. 1 also, where the erosion has been still more severe, this clay-band once existed, but has been entirely cut up, and pushed through and into the gravels; so that here we have really two gravels of different ages, mixed with the relics of a once-dividing clay-band. This view explains many of the peculiarities of the section.

I could not positively determine in what direction the force which wrought these effects had been applied, if indeed the direction were definite at all. But as most of the long tapering protrusions point one way—southward—it is probable that the force did act with some degree of regularity. It is possible that the cliff-line does not cut the beds at a favourable angle, or this might be more striking. The slickenside markings were generally at a high angle to the cliff line, or about W. and E.; whilst the slopes of the bottom of the hollows and the general look of the section seemed to show that the movement had been from the western or landward side. As the ground slopes inland, this would be from a lower to a higher level.

The disturbed masses of Purple Clay seem generally to take the form of wedges, thinning in one or more directions.

These wedges, detached from the main mass, appear in some cases to have been pushed *over* gravels, upturning their edges or entirely contorting and smashing them; in others, to have been forced forward *through* them, so as to cut cleanly without destroying them; whilst sometimes the clay seems to have been squeezed or injected, since the bedding of the gravel curves round the intruder. (*enlarged section* 3 for example).

In many cases I think the gravels must have been frozen hard to allow of so clean a cut; as in the hollow to the left of D, section 1, where the gravel and sand are bedded straight against a vertical wall of boulder clay, with no other disturbance than a single layer of vertical pebbles half fixed in the clay and slightly dragged with it: yet both the sides and bottom of this hollow showed scoring. In some cases it seems to have been masses of frozen gravel that have ploughed into the clay; in others the clay is certainly the intruder. Other evidence of the once frozen state of the gravels is afforded by the somewhat common case in which a thin sheet of gravel stands vertical between beds more or less horizontal, sometimes—as in the enlarged section 3—with a thin and interrupted film of clay forming one border. In these cases the gravel may have been frozen hard to its clayey bed, so that when torn up, it has sometimes dragged a plate of its resting place with it, and has then been tilted and jammed upright, with the clay still adhering to it. In the case of the wedge-shaped masses of clay before mentioned, I think the clay-band may have been broken into huge cubes, and these forced forward till firmly fixed amongst the frozen gravels, and the top may have afterwards been squeezed out or dragged for a little distance further. In some cases a slight movement seems to have taken place during, or after, the deposition of the marls, slightly affecting them; as in one or two places the line between the marls and gravel stands at an angle steeper than I think the marl could be deposited on.*

* This is more evident now than when the section was made.

It is noteworthy that the distortion is greatest under the marls; that is, where the clay and gravel lie lowest; as already mentioned, in proceeding northward the disturbances cease when a higher level is reached. This, combined with other evidence, I think suggests a lacustrine origin for the force movements on the frozen bottom of a shallow lake perhaps.

That an extensive lake, or more probably an extensive series of lakelets with marshy ground between, once existed over the site of Bridlington, and extended for some distance southward, has been abundantly demonstrated during the drainage works in the town; such conditions were once common to the whole of Holderness—the "mershe countree," as Chaucer calls it—and lasted from an indefinite period almost up to the present time; a state of things brought about, not only by the low level of the district and the hummocky irregularity of its surface, but also, I believe, by the former existence of higher ground between it and the sea. This ridge made up of glacial beds, would form a drift-barrier, such as still dams up the seaward edge of the Vale of Pickering and throws back its drainage into the Humber, and such as we have indeed nearly all along the coast north of Flambro', even on the top of the highest Speeton Cliffs. The former existence of this rim is, I think, indicated by the slope of the ground along the Holderness Coast, which is nearly always *from* the sea; thus causing the drainage of Holderness to flow inland, and finally empty itself into the Humber. The high ground still remaining at Dimlington and at one or two other points on the coast, I look upon as the last remnants of this barrier.

Lacustrine and marshy conditions would in this case date from the close of the glacial period; and at that time volumes of water were probably pouring down all the wold valleys, scooping and deepening them—clearing away from them the relics of the hard times past, and spreading their burden of chalky gravel over the low land—bearing often it may be, huge masses of ice and urging forward rough blocks of frozen gravel, to be crushed and

jammed at every sharp curve, and thus exerting great pressure on the frozen slopes of the high land adjoining. Under this view, the fresh-water remains and the patches of older gravel and silt would be readily explained as relics of a time of comparative quiescence; and the fresh-water marls may represent a continuance of the series under changed conditions, the flowing water having been diverted or withdrawn, and having given place to stagnant ponds and marshes.

I must confess, however, that this—like so many theories—looks more plausible when written out, (more plausible, in fact, than I meant it to be) than when applied by one standing before the actual section; many unexplained points or opposing facts remaining now in the background which then stood out prominently. Still it remains the most likely solution that has suggested itself to me and probably contains some truth.

Two years ago, I recorded* the occurrence of freshwater remains in the boulder-clay on the beach between sections 1 and 2, at that time stating my inability to refer them to their place in the series. These remains consisted of fine clayey mud and sandy silt with shells of one species, *Limnæa peregra*, and patches of peat and gravel—the whole greatly disturbed and crushed. These I can now refer with certainty to the base of the gravel No. 2, they having evidently been forced into the boulder-clay in the same way as has the gravel throughout the section. The patches of unstained gravel with silt and peat shown at the base of the enlarged Section 2,† I look upon as fragments of the same bed, and there are more traces of it above the boulder clay in that part of of section 2 south of F.

I have mentioned that what seem to be lines of bedding appear in the Purple Clay near the termination of the middle gravel

* Geol. Mag., Sept., 1879, p. 393.

† The streaks of marly clay with shells, xx of this section are marked 'doubtful,' as the upper part of the section has been disturbed in making the road and the defences, and I thought it possible these might then have been introduced from the marls above, though they seem to be in place.

in Section No. 2. To the south of the town I have traced for some distance in the Purple Clay a band of clay with similar lines, which passes into, or admits, lenticular patches of sand and gravel, and these though at various levels are really on the same horizon, the clay-band resting on, and following the inequalities of an extremely uneven bed. There is a similar band in the Purple Clay on many parts of our Holderness coast, and it may often be traced for long stretches, as for instance, from Witherensea nearly to Dimlington, about three miles; I believe this band forms throughout a definite horizon, corresponding to the still more marked division in the Purple Clay north of Flambro' Head. This clay-band, though often containing scratched blocks, and in all respects a true "boulder clay," certainly does not seem to me to be *moraine profonde*, but a deposit by water,

To other interesting points in these sections I shall no doubt have occasion to revert in describing others, so will not now dwell on them.

I have, in concluding, to thank G. B. Godfrey Esq., the contractor for the new sea-wall, for leave to view the section during the progress of the works, and for his readiness to supply me with any desired information on the subject.

ON SOME SECTIONS IN THE LOWER PALÆOZOIC ROCKS OF THE CRAVEN DISTRICT. BY J. E. MARR, B.A., F.G.S.

THE sections to be described are of great interest, as showing an unconformity at the base of the May Hill beds in Prof. Sedgwick's native district of Craven. The principal section at Austwick has been described by Prof. Hughes, and an unconformity described as existing there, (*Geol. Mag.*, Vol. iv, No. 8.) but an opportunity occurred in the earlier part of this year of more definitely determining the age of the beds just above the unconformity.

At Austwick Beck, (Fig. 1.) the Bala beds (1) are seen in a tributary stream, to be unconformably overlain by a coarse conglomerate, (2) as described by Prof. Hughes, interbedded with thin, black, apparently unfossiliferous shales; the whole reaching a thickness of several feet. Above these is a gradual passage, into black shales, (3) which are also seen in the main stream. They are there overlaid by a thin band of hard blue mudstone, a few inches thick, with calcareous nodules, and containing numerous fossils, among which are:—

Petraia.
Illænus.
Phacops elegans, Bœck and Sars.
Leptæna quinquecostata, Mc.Coy.

Above these are pale green shales, a few feet in thickness, apparently unfossiliferous. They are surmounted by pale blue flags, (6) containing *Monograptus priodon* and *Monograptus vomerinus*, and these by the Austwick grits (7) above which are various alternations of grits and flags.

At Crummack Beck Head, near the last described section, the Bala beds are seen overlain by a similar conglomerate, again with an unconformable junction. Both this conglomerate and that at Austwick Beck consist of a crystalline matrix, with pebbles of various sizes, up to some inches in diameter. Above the conglomerate of Crummack Beck Head are black shales, (Fig. 2, Bed 3.) the top of which is not seen, being covered by vegetation.

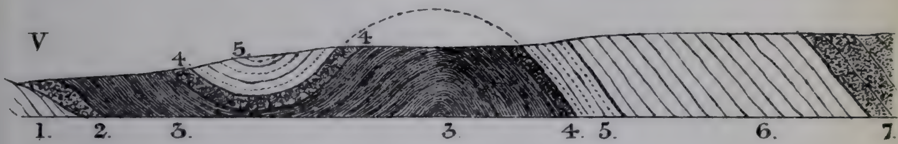
On comparing these beds with those of the neighbouring Lake District, and those of the Sedbergh District, we find no difficulty whatever in correlating them.

The conglomerate of Austwick Beck is replaced by calcareous grits and conglomerates near Sedbergh, and by a thin calcareous bed, sometimes containing included fragments in the Lake District.

In Spengill near Sedbergh, and in Torver Beck, near Coniston, a thin blue band occurs between the black graptolitic mudstones, and the pale slates. This band in every respect resembles

Fig. I.

Section in Austwick Beck.

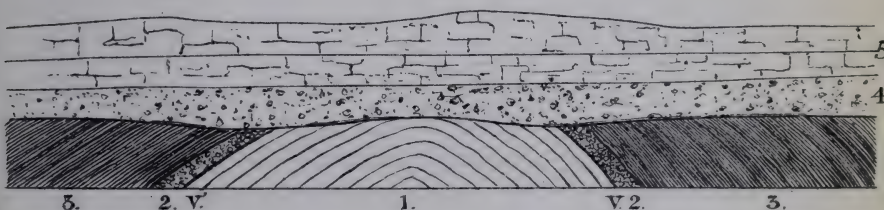


1. *Bala Beds.*
2. *Conglomerate with interbedded Black Shales.*
3. *Black Shales.*
4. *Hard Mudstone with Calcareous Concretions (Zone of P. elegans)*
5. *Pale Green Shales.*
6. *Blue Flags (Monograptus priodon.)*
7. *Grits*

V. *Unconformity.*

Fig. II.

Section at Crummack Beck Head.



1. *Bala Beds.*
2. *Calcareous Conglomerate.*
3. *Black Shales.*
4. *Carboniferous Conglomerate.*
5. *Carboniferous Limestone.*

V.V.' *Unconformities.*

A. Megson, Litho. Leeds.

that of Austwick Beck, (Bed 4 of Sections.) and like it, contains:

Petraia.
Phacops elegans.
Leptæna quinquecostata, &c.

The occurrence of Phacops elegans, a characteristic May Hill form on the continent, now recorded for the first time in English beds is quite sufficient to give the date of these beds at Austwick, for I have found it at various parts of the Lake District. and also in Central Wales, as described by Mr. W. Keeping, (*Q.J.G.S.*, 1881.) in every case occurring in beds containing graptolites of Birkhill type. The lithological resemblance of the beds above and below this Phacops elegans zone at Austwick, with the graptolitic mudstones and Pale slates respectively, in the Lake District is very apparent.

Finally, the age of these beds is proved by their being succeeded conformably by beds of similar lithological character to the Brathay flags of the Lake District, and containing the same species of graptolites as do those beds. The beds succeeding these priodon-bearing flags can also be correlated with the Coniston flags and grits of the typical area. There is therefore no doubt that the unconformity described by Prof. Hughes, as occurring in the Austwick district, really does occur between the Bala beds and the May Hill group.

In conclusion, the beds from the base of the conglomerate up to the base of the priodon-bearing flags are so inseparably bound together at Austwick, that they ought certainly to be included in one group, similarly the equivalents of these beds in the Lake District are grouped together as Stockdale shales, and the pale shales of the Stockdale Valley contain fossils of undoubted Birkhill type, *(Monograptus lobiferus, M. turriculatus)* thus bearing out the classification of Prof. Lapworth, who unites the May Hill beds with the pale slates or Tarannon shales, to form one great group of the Silurian system.

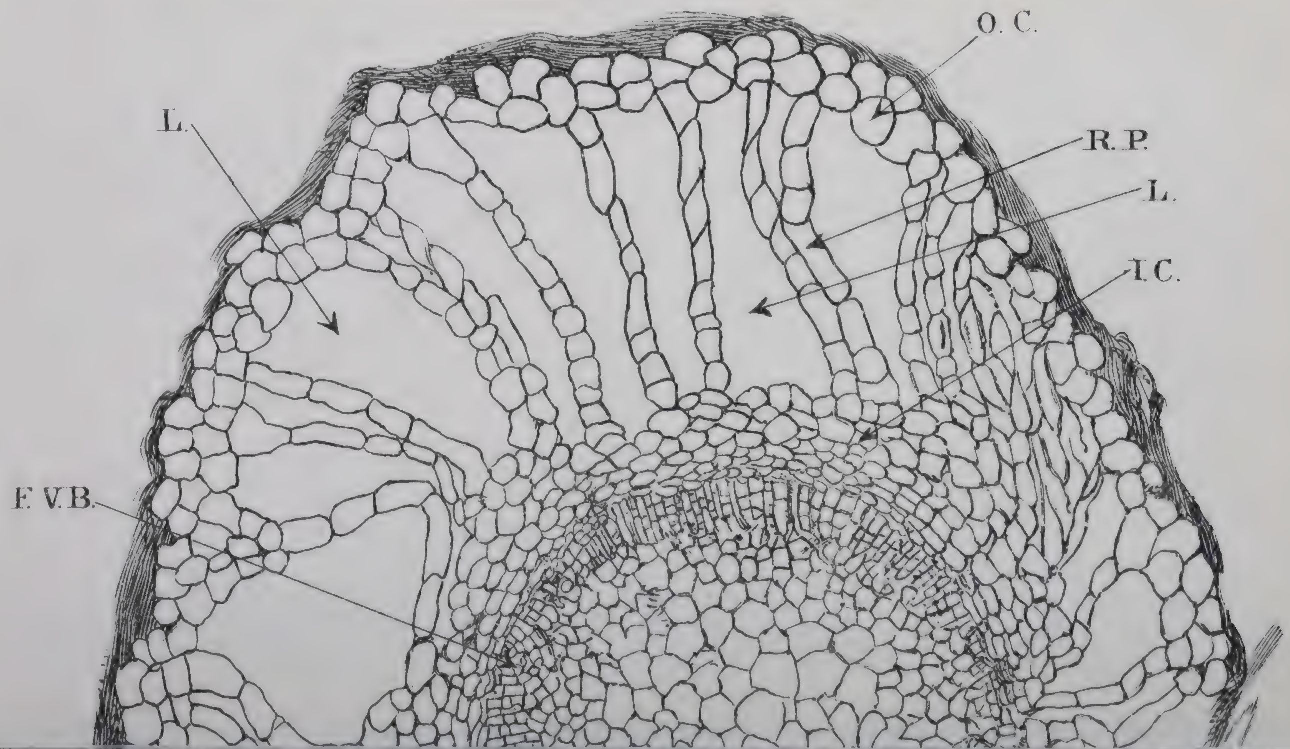
A CONTRIBUTION TO THE FLORA OF THE LOWER COAL MEASURES OF THE PARISH OF HALIFAX, PT. III. BY THOS. HICK, B.A., B.SC., (LOND.) AND W. CASH, F.G.S.

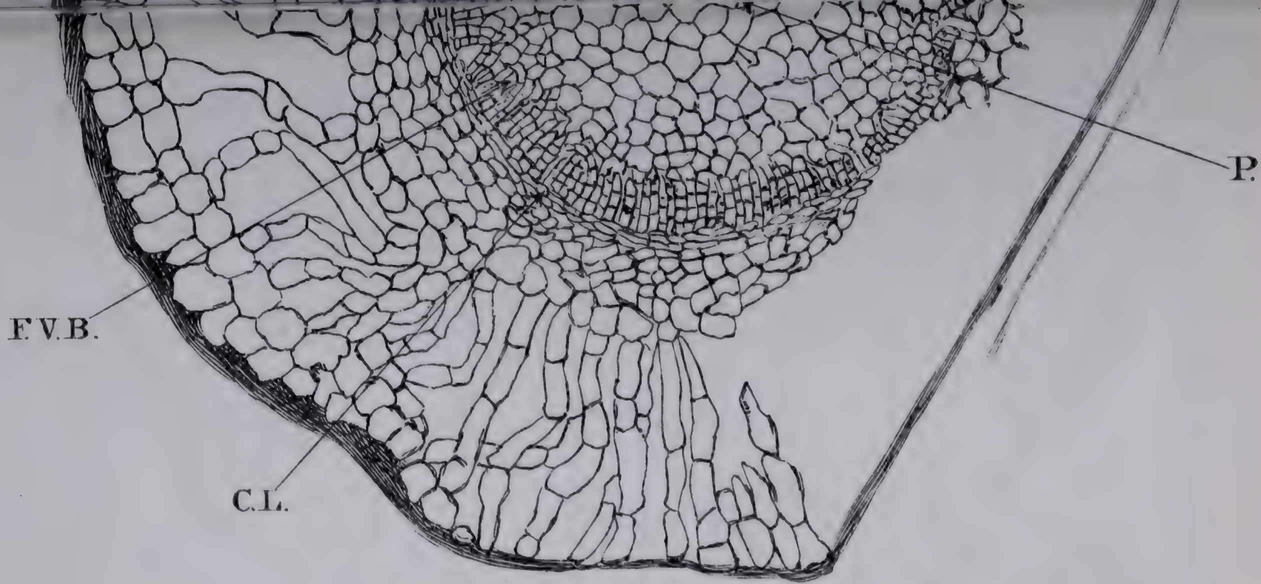
THE active explorations which for several years have been going on in the Halifax Coal Measures, and which have produced no small proportion of the materials on which our present knowledge of the Carboniferous Flora is based, have lately resulted in the discovery of a small fragment of what appears to be a fossilised vegetable stem or branchlet, which has not been previously described, and which, from the peculiarities of its organisation, cannot fail to be of interest to palæobotanists.

The mineralised material from which the fossil has been obtained, was extremely small in quantity, and only allowed of four sections suitable for microscopical examination being made from it. Of these sections, three have been taken transversely across the supposed stem, while the fourth is longitudinal, but very oblique. The three transverse sections, however, have been made so close to one another, that they exhibit few or no important differences *inter se*, and may practically be regarded as the same section. From this it will be obvious how scanty are the materials we have had at our command in framing a description of this new, and, as we think, important fossil; and how extremely limited have been our means of verifying the few inferences we have ventured to draw from the structural appearances it presents. Still, as the same remark is applicable to a considerable number of the fossil plants that have been described in recent years, we can hardly hesitate on this ground, to give publicity to the existence of our specimen, and to furnish those interested in the subject with such an account of its structure and supposed affinities, as a careful examination of the sections has enabled us to draw up.

1. *General description.*—Though somewhat flattened on one side and imperfect on the other, the stem is sufficiently well preserved to indicate that it was originally cylindrical in its general form, but there is nothing to show what was the condition of the external

MYRIOPHYLLOIDES WILLIAMSONI.





Description of Plate.

P. — *Pith.*
F. V. B.— *Fibro-vascular Bundles.*
C. L. — *Cambium Layer.*
I. C.— *Inner portion of Cortex.*
R. P.— *Radial Plates.*
L. — *Lacunæ or Air Canals.*
O. C — *Outer portion of Cortex.*

surface. It consists of a central pith, surrounded by a number of slightly wedge-shaped masses of tissue, which are either of a fibro-vascular or of a wholly-vascular character. Outside these masses of tissue or bundles, as we may term them, is a cambium ring, followed by a comparatively thick cortex. This is composed, in a great measure, of radiating plates composed of cells, with large intervening longitudinal air cavities, similar to those met with in recent aquatc plants. The cellular plates do not anastomose, so that the air cavities are continuous from the central axis to the peripheral portion of the stem, which is composed of a few layers of somewhat rounded cells. The dimensions of the stem—full particulars of which are given at the end of the paper—are comparatively small, the whole diameter probably not exceeding $\frac{3}{20}$ of an inch.

2. *Special description.* 1. *The Pith.*—The pith is composed of cellular tissue, which in all essential particulars is similar to that met with in recent herbaceous stems during the growing season, and in the youngest shoots of woody perennials; that is to say, the cells are of a rounded or polyhedral form, with a few very small intercellular spaces, and with thin walls. As is not uncommon in such stems, the cells at the periphery of the pith have slightly thicker walls than those which occupy the centre. The size of the cells is by no means uniform, but varies from ·0028 inch to ·0056 in diameter. The longitudinal section shows very few of the pith cells, but from such as are present it would seem that they were somewhat elongated in that direction.

2. *The wedge-shaped masses of tissue or bundles.*—These are arranged side by side in a circle which surrounds the pith, and bear a remarkable resemblance to the xylem portions of the fibro-vascular bundles of dicotyledons during the first season of growth. They are composed of elements, which in the transverse section appear as small, thick-walled, generally square cells, arranged four or five deep in radiating lines. The breadth of the zone formed by the bundles is about ·007 of an inch. In the longitudinal section the bundles are seen to be made up of elongated vessels, the mark-

ing of whose walls is not quite uniform, but is chiefly of the barred and dotted types. These vessels seem to be intermixed with a few elongated cells, of a more fibrous character, with plain walls; but our preparations are not quite decisive on this point. The pith and bundles combined form a central cylindrical axis to the stem, which has a diameter of ·056 of an inch.

3. *The Cambium layer.*—External to the bundles, and separated from them by a somewhat sharp line of demarcation, is a thin stratum of delicate cells which again recalls the structure of young dicotyledonous stems and branchlets. It forms a continuous ring, enclosing the whole of the bundles; and though from the delicacy of the tissue it has not been equally well preserved throughout, it remains in sufficient perfection to show its close similarity, if not identity, with the cambium layer of the stems referred to.

4. *The Cortex.*—This part of the stem is the one that gives it its distinctive character, and that exhibits a structure which, so far as we know, has not been previously met with in fossil plants. As will be seen by comparing the total diameter of the stem with that of the central axis, the cortical layer is of considerable thickness in proportion to the other tissues. For the purposes of description, it may be said to consist of an inner, a median, and an outer portion, which, though intimately connected with one another, and forming parts of the same tissue, are nevertheless in marked contrast.

The inner portion is composed of cells which are slightly elongated in a tangential direction, and have some likeness to those met with in the cortical parenchyma of dicotyledons. Internally it abuts on the Cambium layer, but it appears to be wholly destitute of fibrous elements, and of anything which can be regarded as the homologue of the bark of ordinary phanerogams.

The median portion, seen in transverse section, consists of a number of radiating filaments, composed of cells, united end to end, which connect the inner with the outer portions of the cortex.

Between these filaments are spaces destitute of tissue of any kind, which are obviously the sections of large air cavities, which run longitudinally through the stem. The longitudinal section is hardly so demonstrative as we could have wished, but it leaves no doubt on our minds that the radiating filaments are merely the transverse appearances of longitudinal plates of parenchymatous tissue, that form the lateral boundaries of the air cavities. As we have mentioned above, these plates do not anastomose with one another, but run free from the central axis in radial directions.

The outer part of the cortex is not well represented in any of our preparations, the stem having been compressed and probably undergone some surface disintegration previous to fossilization. Moreover it is so closely intermixed with other fragments of vegetable tissue, that its limits are not strictly definable. Nevertheless, enough of the peripheral cortex still remains to enable us to state that it was partly, and most probably, wholly cellular.

3. *Probable Affinities.*—In venturing to speculate on the probable affinities of the plant, whose stem has the structure and organisation just described, we are not unmindful of the difficulty, not to say danger, of so doing without a knowledge of the structure and arrangement of its other organs. Undoubtedly in the absence of these it is impossible to determine with certainty its systematic position, or even to speak with full confidence of the class to which it must be assigned. But this we opine is no reason why we should refrain from at least pointing out the *resemblances* which we find between the organisation of this stem, and that of certain recent forms with which all botanists are familiar. We allude to such well known forms of acquatic plants, as *Myriophyllum*, *Hippuris*, *Potamogeton*, and a few others. In most of these the stem exhibits an axial string of fibro-vascular bundles, surrounded by a cortex of comparatively large dimensions, which is traversed longitudinally by a number of large cavities. These cavities are divided one from another by parenchymatous lamellæ, one cell thick, which in some cases run direct from the axial string to the outer layers of the

cortex, and in others anastomose freely. Comparing our fossil with these plants, we find that it has many points of resemblance to the stem of *Myriophyllum*. In both there is an axial string, composed of fibro-vascular bundles, and a comparatively thick cortex, in which are longitudinal cavities, separated by thin plates of parenchyma. In histological structure, the cortex of both the recent and the fossil form is almost identical. The axial string, however, is not quite the same in the two cases. In the fossil it exhibits a distinction into pith and fibro-vascular bundles, which, as we have already said, are arranged somewhat as in dicotyledons. But in *Myriophyllum* the axial string is composed of a thin-walled cambiform tissue, and is enclosed in a well defined fibro-vascular bundle sheath. There is, however, no distinct separation of pith and bundles as occurs in the fossil specimen, nor is there anything comparable to a cambium zone. This is no doubt a most important difference, and one to which we are disposed to attach considerable weight. The form of the bundles, and presence of the cambium, seem to indicate that the fossil plant was capable of growing in diameter in the same manner as an ordinary dicotyledon, but this can hardly be said of the modern *Myriophyllum*.

For this addition to our Fossil Flora, we have once more to record our thanks to our indefatigable friend, Mr. James Binns, of Warley, near Halifax, who has already furnished us with several new forms.

In honour of Professor W. C. Williamson, F.R.S.. who has done so much by his labours and prolonged investigations to elucidate the organisation of Carboniferous plants, we propose to designate our specimen,—" *Myriophylloides Williamsoni*."

TABLE OF DIMENSIONS.

Diameter of pith alone	·042 inch.
Breadth of vascular zone ...	·007 ,,
Diameter of axial string ...	·056 ,,

Breadth of inner cortical zone	·007 inch.	
,, middle ,, ,,	·0245	,,
,, outer ,, ,,	·014	,,
Total breadth of cortex	·0455	,,
Total diameter of stem	·147	,,

Diameter of axial string = $\frac{8}{21}$ of whole diameter.

NOTE.—In a letter to *Nature*, (vol. 25, p. 124), Prof. Williamson, to whose encouragement and advice we are much indebted, suggests that the generic name, *Myriophylloides*, should be changed to *Helophyton*. This he does on two grounds :—1st, that *Myriophylloides* is likely to suggest improbable affinities, and 2nd, that Unger has already employed a very similar name—*Myriophyllites*—for a genus of Tertiary plants. We are are not quite convinced of the advisability of the change on the grounds specified, but bow to the superior judgment and maturer knowledge of our kind and genial leader.

The question of affinities to which Prof. Williamson incidentally alludes, can only be settled by the study of additional specimens; but we may point out that the structure of the axis of our interesting fossil is strongly suggestive of Dicotyledonous relationships.

ON CERTAIN DISCOVERIES OF BRONZE IMPLEMENTS IN THE NEIGHBOURHOOD OF LEEDS. BY JOHN HOLMES.

IN May last (1881), a labourer in digging a trench by the side of an ancient foot-path going from the Carr Moor side, Hunslet, to Beeston Churwell and Morley, near Leeds, at about 10 feet 6 inches deep in clay, came upon a hoard of nine bronze implements. Eight are of the Palstave and one of the Socketed Celt types—all of which I fortunately obtained and now exhibit.

In May, 1878, in tunneling under the River Aire at Thwaite Gate, Hunslet, about a mile S.E. of the preceeding, at about 20 feet deep in sand, a well formed spear head was discovered. Again in May, 1846, a discovery of bronze weapons occurred, when

excavating on a line of the Leeds and Dewsbury Railway at Churwell, a short distance outside the Borough of Leeds, consisting of three spears and five palstaves. An account published in the "Gentleman's Magazine" stated that there were nine axe and four small javelin-heads, but James Wardell, Esq., Deputy Town-Clerk of Leeds, who investigated on the spot, and who obtained these now shewn, concurs in the statement given above (See "Historical Notes" 1869). Mr. Wardell also observes that "Some years ago, a large and heavy Bronze palstave was found in a garden at Morley, along with a gold coin of that period." (Historical Notes, p. 42, 1869) The Celt is here, measuring as he says, "Seven inches in length, and weighing twenty-one and three-quarter ounces," but nothing more being said, the gold coin, I think is doubtful.

In the collection of the Leeds Philosophical Society there is a Bronze palstave, marked Churwell, exactly like these of the Hunslet Carr types.

While making a lock for the Canal of the Aire and Calder Navigation, about 5 miles N.E. of Wakefield, one of the most beautiful Bronze Daggers known was discovered at 22 feet deep, beneath silt containing oak-trees, gravel, sand, and soil. This was in 1842, and is further interesting from the fact, that in 1818 at Stanley Ferry, only 2 miles above where the dagger was found, a Canoe boat made from a solid oak, was found, the remains of which may now be seen in the Ethnological room of the York Museum. Still further south, 5 or 6 miles, at the other side of the Calder, in ploughing a field at the base of the hill upon which stands the Castle of Sandal Magna, a very interesting type of Bronze Celt was found about the year 1852.

The above list is very far from complete, and only given to shew the extensive distribution of the Bronze Implements in this portion of Yorkshire.

Reverting to the positive evidences before us, and taking

advantage of the classifications laid down by Mr. Evans,* we may say, that the Sandal Magna Celt is of an early and simple type. It is finely palmated, measures 5⅝ inches long, and weighs 13 ounces.

The earliest and simplest type figured by Mr. Evans is like one which I obtained at Cyprus in 1873. Such an implement placed in any knob or handle of wood, would tend in use to split it along the grain of the wood. To prevent this, a series of progressive contrivances are exhibited in Bronze Celts, which by swelling the surface, or by flanging the sides, or across, would tend to prevent splitting from a direct stroke or blow of the implement, and so give efficiency for its use. The Celt now before us (the Sandal specimen) shews an interesting stage of transition, viz., the slight thickening from the ends to the centre; a slight ridge across the centre, and a well defined side flange, partly cast and partly hammered,—while much decayed, affords evidence of a hollow-ridged-ornament running across the flanges—such as Mr. Evans figures in No. 7 from Suffolk, No. 12 from Norfolk, No. 14 from Lewes, No. 15 from Ely, No. 17 from Liss, and several from Scotland and Ireland. The general form of this Celt is common over the British Islands, and in Denmark, and may be considered a good specimen of the second or third stage of progress.

The whole of the Hunslet-Carr hoard, save the socketed one, are of the latest and best form of the palstaves. They have been cast with sunken hollows—to fix in a split handle—with a well shaped cross flange in the centre to prevent splitting; and they have each a loop to tie to, or to steady the head upon a handle. The cutting edge is well shaped—being worn most by use on the side opposite to the loop. They are slightly ornamented in casting, by a simple ridge, and in one instance a V shaped shield below the cross flange, all economising material, while strengthening the Celt itself. One has further, at the handle end, a small piece notched

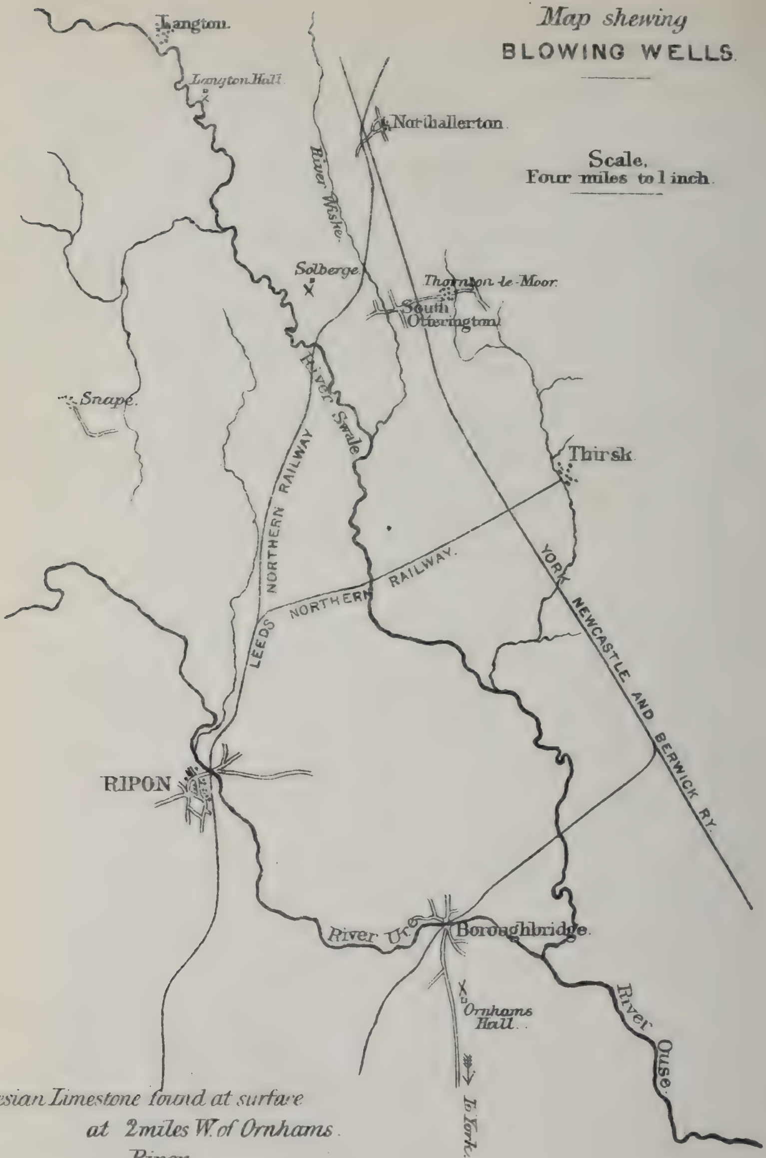
* "Ancient Bronze Implements, Weapons, and Ornaments of Great Britain," (1881).

out on each side, leaving a sort of wedge in the centre, which would tend to fix and steady it in the handle. They measure from $5\frac{1}{2}$ to $7\frac{1}{4}$ inches in length, and weigh from 12 to 17 ounces. The range of such palstaves is very extensive, perhaps most numerous in Sweden and Denmark, very numerous in Ireland, and frequent in both Scotland and England. Mr. Evans figures many such at pp. 88-9, 90-1, &c.

The Socketed Celt has nothing very especial in it, except that it is larger than the average, being $4\frac{3}{4}$ inches in length, and weighs 10 ounces. It has a V shaped ornament in the casting, from the collar of the socket, to the cutting edge; and others thus figured are given by Mr. Evans at p. 128. The range of such Celts is like the palstave widely spread; and France shews a considerable variety. In Great Britain they are frequent, but perhaps not so numerous as the palstave form, upon which it appears to be a later advance, obviating any tendency to splitting the handle by use. Mr. Evans figures the mode of their handling in Nos. 184, 5, 6 and 7, and such like handling may be seen in use upon the Egyptian pictures in the tombs near the pyramids, and at Beni Hassan and Thebes.

The large palstave found at Morley, and the six or eight, including the spear heads, found at Churwell in the Railway cutting, deserve a more careful examination. Some are just rough cast, with the fringe edge of the metal left, as it escaped into the imperfectly closed edge of the core or mould, in which they were cast. Some are hammered and finished, and the spears have evidently undergone a slight process of hammering at the edges, to make them ductile, tough, and sharp.

The range of this form of implement is very extensive. Examples are numerous in Norway and Sweden, and Ireland, as well as in England and Scotland. Mr. Holmes is of opinion that the Socketed Celt may perhaps be associated with the Semetic tribes recorded in history, and of the long-skulled prehistoric people, and concluded with a number of speculations as to the character and state of civilization of the early tribes using bronze implements in Britain.



Magnesian Limestone found at surface

at 2 miles W. of Ornhams.

„ Ripon.

„ Snape, 6 miles S.W. of Solberge.

„ a depth of 479 feet at Thornton-le-Moor.

„ 4 miles E. of Solberge.

„ Northallerton about 400 feet from surface.

ON THE BLOWING WELLS NEAR NORTHALLERTON. BY T FAIRLEY, F.R.S.E.

THE wells are three in number.

Well at Solberge, $3\frac{1}{2}$ miles southward from Northallerton.

Well at Langton, about 4 miles W.N.W. of Northallerton.

Well at Ornhams, about 2 miles southwards from Boroughbridge.

They are called blowing wells because in each of them currents of air flow from the shafts of the wells during a falling period of the barometer, and inward currents flow into the shafts of the wells while the barometer is rising. When the rise or fall of the barometer is considerable, the currents are very powerful, producing a strong draught or wind in the openings leading to the shaft.

Through the kindness and assistance of Mr. Hutton, the proprietor of the estate at Solberge, I have been able to make a number of experiments at the well near the house at Solberge.

In the first instance I analyzed the water from the well taken by Mr. Hutton, on the 12th of June, 1879.

The water contains in grains per gallon :—

	Chlorides, consisting of common salt ..	4·1	containing Chlorine 2·49
	Sulphate of Lime	6·36	
	Carbonate of Lime	16·24	
	Carbonate of Magnesia	11·36	
	Oxide of Iron and Alumina	0·03	
	Silica	0·21	
(1)	Organic Matter, &c.	0·34	(by difference)
	Total Solids by evaporation...	38·64	
(1)	Containing Ammonia	none	
	Containing Organic Ammonia	0·0014	

Colour of the water in 2 foot tube, very slight green tint.

Hardness of the water before boiling, 32°·6; after, 8°·4, giving temporary hardness 24°·2; permanent 8°·4; total 32°·6.

The analysis shows that it is a water having a composition similar to those coming from chalk or limestone strata.

I have also on various occasions analyzed the air proceeding from the well both with a portable eudiometer on the spot, and also of a sample taken at the beginning of these experiments by Mr. Hutton. In each case the analysis did not differ appreciably from that of ordinary air, and gave 20·9 per cent of oxygen. There was no excess of carbonic acid. I was informed, however, that when the shaft of the well was first sunk there was a great and sudden outrush of choke damp, so that the well sinkers barely escaped with their lives. These facts, and the information I had as to the great force and quantity of the current following on the changes of the barometer, led me to suggest the existence of a large cavity in the strata communicating with the shaft of the well. In February, 1879, when the well was opened in my presence we found the fissures in the sandstone near the water line at a depth of 15 yards from the surface. The well then contained about 6 feet of water. The out-current shown by a lighted candle held to the fissure was very powerful.

Observations were made dependent on the application of Boyles' law to measure the out or in current, so as to get an approximation to the size of the cavity, first with a vane anemometer, afterwards with large gas meters. Only these readings are of use for this purpose where a current due to a change of the barometer has had full time to expend itself.

In many cases the current is checked or modified by subsequent barometric changes.

Considering the difficulty of closing a well shaft covered with stone flags so as to be air tight, and that readings could be taken only at intervals, generally in the morning and afternoon, the measurements can only be regarded as approximate. Of course the assumption was made that no other openings or fissures led into this cavity.

Readings were also made of the temperature of the out-currents, and of the temperature of the atmosphere. I fear, however, that the temperature of the out-currents was more dependent on

that of the piping, fittings, and water of the well than upon that of the cavity whence it proceeded.

It was observed that in winter the out-current was warmer than the temperature of the air, and in warmer weather it was frequently colder.

The vane anemometer obtained from Davis, Optician of Leeds, was found on preliminary testing to be tolerably accurate or sufficiently so for the purpose. In the first experiments the anemometer was allowed to work continuously, and the following are the results :—

The instrument was placed in a horizontal pipe (square at the end) connected with the casing of the pump.

Date.	*Hour.*	*Bar.*	*Temp. Air.*	*Anemt. Readings.*	*Direction of Current.*
1879. July 3	10-0 p.m.	29·425	51·5		
,, 4	9-0 a.m.	·45	.57	22,189	in
,,	12-0 a.m.	·525	·59	82,929	in
,,	6-30 p.m.	·625	·56	274,266	in
,,	10-0 p.m.	·675	·53	411,182	in
,, 5	10-20 a.m.	·75	·54	843,225	in
,,	4-40 p.m.	·80	·55	1,068,290	in
,,	10-40 p.m.	·875	·51	1,247,429	in
,, 6	10-40 a.m.	·925	·60	1,645,673	in
,,	4-50 p.m.	·875	·61	1,832,936	in
,,	8-20 p.m.	·825	·55	1,857,095	in, very slow Stp'd 3 hrs. later

Here a total rise of the barometer of the 0·4 inches caused an in-current of 1,857,095 linear feet, measured by the anemometer. The sectional area of the pipe where the instrument was placed was about ·085 square feet.

Calculated volume of cavity —

$$1{,}857{,}095 \times \cdot 085 \times \frac{29{,}825}{0\cdot 4} = 11\cdot 76 \text{ millions of cubit feet.}$$

A second set of readings with an out-current from July 6th, 1879, at 10-20 p.m., to July 9th, at 10 a.m., when the current was nearly stopped, but not quite finished, gave initial bar, 29·8; final, 29·275; anemometer reading, 2,285,338; temperature of air, average 57·7: temperature of out-current, average 55·2; calculated volume of cavity, 11 millions of cubic feet nearly.

Table I gives another set of readings from December 4th to 16th, 1879, in which the anemometer gave the velocity of the current at the times of observations.

Working out the results from December 3rd, to December 9th, we obtain the following results.

Observations with anemometer:—

December 5th to 9th inclusive, v = velocity per minute in linear feet.

December 5th, at 5-42 p.m., barometer stationery. Observed velocity at 10-30 a.m., December 6th, 835·4 ∴ mean v. for 16 hours 48 minutes $= \dfrac{835{\cdot}4}{2} = 417{\cdot}7$.

Total feet passed = 417·7 × 1008 = 421,041.

December 6th, 10-30 a.m. to 5 p.m. = 6½ hours. Mean $v. \dfrac{835{\cdot}4 + 845{\cdot}8}{2} = 840{\cdot}6$.

Total feet passed 840·6 × 390 = 327,834.

December 6th, 5 p.m., to 7th, 10-30 a.m., 17½ hours. Mean $v. = \dfrac{845{\cdot}8 + 665{\cdot}6}{2} = 755{\cdot}7$.

Total feet passed 1050 × 755·7 = 793,485.

December 7th, 10-30 a.m. to 5-30 p.m. = 6 hours. Mean $v. \dfrac{665{\cdot}6 + 486{\cdot}6}{2} = 576{\cdot}1$.

Total feet passed 576·1 × 360 = 207,396.

TABLE I.—WELL AT SOLBERGE.

Mr. Hutton's Observations, December 4th-16th, 1879.

Date.	*Hour.*	*Bar.*	*Temp. of Current.*	*Temp. of Air.*	*Direct'n of Current.*	*Velocity per Minute by Anemt. in Feet.*	*Mean Velocity. Feet.*	*Corrected Ft. per Minute.*	
Dec. 4	10-30 a.m.	29·77	24° F.	11° F.	out	256, 256, 246, 255, 250	252·6 out	255	
,, 5	10-30 a.m,	29·55	23	20	out	358	358 out	359	
,, 6	10-30 a.m,	30 025	—	15	in	847, 814, 835, 835, 846	835·4 in	834·4	
,, 6	5 p.m.	30 175	—	16	in	849, 840, 848, 848, 844	845·8 in	845	
,, 7	10-30 a.m.	30·375	—	2	in	681, 664, 673, 657, 653	665·8 in	665	
,, 7	4-30 p.m.	30·375	—	16	in	487. 453, 494, 503, 487	486 6 in	486·6	
,, 8	10-30 a.m.	30·525	—	33	in	476, 474, 496, 485, 469	460 in	460	
,, 8	4-30 p.m.	30·525	—	33	in	408, 399, 395, 389, 402	398·6 in	398	
,, 9	10-30 a.m.	30·475	—	27	none	none	none		
,, 9	4-45 p.m.	30·4	—	27	out	249, 233, 227, 223, 229	232·2 out	235	
									Stationary at 11-53 p.m, Bar. 30 462.
,, 10	10 a.m.	30·55	—	35	in	327, 326, 330, 329, 331	328·6 in	330	
,, 10	6 p.m.	30·6	—	26	in	284, 270, 276, 270, 270	274 in	276	
,, 11	10 a.m.	30·575	—	13	in	183, 193, 182, 179, 190	185·4 in	189	
,, 11	6 p.m,	30·575	—	21	in	139, 152, 143, 162, 147	149 in	154·4	
,, 12	10 a.m.	30·675	—	24	in	354, 356, 353, 356, 349	353·6 in	354·6	
,, 12	5-30 p m.	30·75	—	29	in	331, 330, 349, 330, 338	336·6 in	338	
,, 13	11 a.m.	30·75	—	27	in	53, 56, 59, 62, 53	56·6 in	72	
									Stationary at 12-12 Bar. 30 73.
,, 13	5-30 p.m.	30 65	35	31	out	263. 258, 243. 247, 248	251·8 out	254	
,, 14	10 a.m.	30·45	39	40	out	275, 297. 296, 297, 299	292·8 out	294	
,, 14	6 p.m.	30 4	42	39	out	306, 312, 297, 286, 289	292 out	293	
									Stationary at 5 a.m. Bar. 36 45.
,, 15	10 a.m.	30·475	—	37	in	116, 129, 126, 119, 127	123 4 in	130	
,, 15	6-30 p.m.	30·525	—	36	in	156, 148, 150, 150, 152	151·2 in	157	
,, 16	9-30 a.m			36	none	none	none		

December 7th, 5-30 p.m., to 8th, 10-30 a.m. = 18 hours.

$$\text{Mean } v. \frac{486{\cdot}6 + 460}{2} = 473{\cdot}3.$$

Total feet passed 473·3 × 1080 = 511,164.

December 8th, 10-30 a.m. to 4-30 p.m. = 6 hours. Mean

$$v. \frac{460 + 398{\cdot}6}{2} = 429{\cdot}3.$$

Total feet passed 429·3 × 360 = 154,548.

December 8th, 4-30 p.m., to 9th, 10-30 a.m. = 18 hours.

$$\text{Mean } v. \frac{398{\cdot}6 + 0}{2} = 199{\cdot}3.$$

Total feet passed 1080 × 199.3 = 215,244.

December 9th, 10-30 a.m. to 11-53 p.m., 13 hours 23 minutes.

$$\text{Mean } v. \frac{232.2 + 0}{2} \; 116{\cdot}6.$$ Barometer finally at 30·462.

Total feet passed 116·6 × 803 = 93,630.

Therefore, total feet passed from December 5th, at 5-42 p.m. to December 9th, at 11-53 p.m $= 2{,}724{,}342 \times {\cdot}085 \times \frac{30{\cdot}462}{{\cdot}762}$ (area of tube) $= 9\frac{1}{4}$ millions of cubic feet.

Similar calculations (which can be checked from the table already given) referring to the in-current from December 10th, 1879, to December 13th, the initial barometer being 30·4, and the final 30·75, give $1{,}185{,}153 \times {\cdot}085 \times \frac{30{\cdot}75}{0{\cdot}35} = 11{\cdot}5$ millions of cubic feet.

The other observations evidently refer to currents which the subsequent changes of the barometer did not allow to be completed.

Assuming that the covering of the shaft of the well was air-tight, which was frequently not the case, we have here a

mean result of about 10 millions of cubic feet of space as that of the cavity affected by the barometric changes.

Of course if there be any other unobserved openings into this cavity, the area of the enclosed space must be so much the larger in proportion to the amount of air passing by other ways.

In February, 1880, I took two of the largest dry meters in the possession of the Leeds Corporation, not in actual use at the time, coupled so that one registered the in, and the other the out-current It was found, however, that these meters were so greatly strained by the force and quantity of the current, that they were soon thrown out of gear from their incapacity to pass the quantity of air fast enough. The air also forced its way out under the flags covering the well. Indeed at first the meter passed about double the quantity of air which it was constructed to do to give an approximately accurate measurement.

Mentioning my difficulty to Mr. Glover, of the firm of Messrs. Glover & Son, Dry Meter Manufacturers, of London, he kindly placed two large meters, constructed to pass 3000 cubic feet per hour at the maximum, and I had these coupled to the pipe from the shaft of the well as before, one to register the out, and the other the in-current. Mr. Hutton took frequent readings of the barometer and of the air registered by the meters.

Table II is simply a tabulated copy of the results noted by Mr. Hutton according to my instructions.

TABLE II.—OBSERVATIONS AT SOLBERGE WITH LARGE GAS METERS.

Date,	Hour.	Current.	Bar.	Temperature.		Pressure,		Cubic Feet, In.	Cubic Feet, Out.	Remarks.
				Air.	Tube.	In.	Out.			
1880.										
Mar. 25	4 p.m.	out	30·10	50°F	56°·5F		·05		2700	
,, 26	9-30 a.m.	out	·04	38	40		nil		10,500	
,, 26	6 p.m.	nil	·04	43	44		,,		13,100	
,, 27	10 a.m.	in	·06	39	44	nil		3000	13.100	
,, 27	6-30 p.m.	nil	·06	39	44	,,	,,	3500	13,400	Stationary at 2 a.m., 28th.
,, 28	9-30 a.m.	out	·06	40	42	,,	,,	4400	14,300	
,, 28	6 p.m.	out	29·94	46	46	,,	,,	,,	21,700	
,, 29	9-30 a.m.	out	·86	46	46.5	,,	,,	,,	36,400	
,, 29	6 p.m.	out	·82	50	49	,,	,,	,,	45,200	
,, 30	9 a.m.	out	·83	47	48	,,	,,	,,	50,600	
,, 30	6-30 p.m.	out	·72	49	48	,,	,,	,,	59,200	
,, 31	9-30 a.m.	out	·31	44	45	,,	,,	,,	89,000	
,, 31	6-30 p.m.	out	·10	46	46	,,	·10	,,	112,700	
April 1	9-30 a.m.	out	·20	46	46.5	,,	·05	,,	141,400	Outlet stopped, 12-30.
,, 1	7-30 p.m.	in	·40	43	46,5	,,	,,	6100		Inlet began, 4-30. Still at midnight. Bar. 29·34.
,, 2	10-30 a.m.	out	·21	43	45			9800	150,400	
,, 2	6-30 p.m.	out	·15	48	47.5				162,600	
,, 3	10-30 a.m.	out	·24	54	54				170.300	
,, 3	6-30 p.m.	out	·23	52	51				174,600	
,, 4	9-30 a.m.	out	·06	45.5	46				191,000	
,, 4	6 p.m.	out	·09	48	51				201,600	
,, 5	9-30 a.m.	out	·10	45.5	45.5				208,000	
,, 5	7 p.m.	out	·05	44	45				215,500	
,, 6	9 a.m.	nil	·05	45	45				224,100	Turned at 4-36. Bar. 29·05.

TABLE II.—(*Continued.*)

Date.		*Hour.*	*Current.*	*Bar.*	*Temperature,*		*Pressure,*		*Cubic Feet, In.*	*Cubic Feet, Out.*	*Remarks.*
					Air,	*Tube.*	*In,*	*Out,*			
1880.											
April	6	6-30 p.m.	in	·09	45	45°F.			10,100	225,300	
,,	7	9-30 a.m.	in	·22	48	,,			19,000	,,	
,,	7	6-30 p.m.	in	·43	43	,,			31,300		
,,	8	10-30 a.m.	in	·85	49	,,	·10		72,100		
,,	8	11-30 a.m.	in	·85	49	,,	·15		75,200		
,,	8	6 15 p.m.	in	·99	45	,,	·15		96,400		
,,	9	9-15 a.m.	in	30·17	44	,,	·15		144,000		
,,	9	7 p.m.	in	·17	40	,,	·15		170,100		
,,	10	10 a.m.	in	·16	48	,,	·10		194,100		Current changed at 2-45, Bar. 30·1.
,,	10	6-30 p m.	out	·05	45	45			196,500	227,200	
,,	11	9 a.m.	out	29·92	45	47				237,600	
,,	11	6-30 p.m.	out	·88	44	47				244,100	
,,	12	9-30 a.m.	out	·85	42	42				248,700	
,,	12	6-30 p.m.	out	29·80	42-5	43				255,100	
,,	13	9-30 a.m.	out	·81	42	42·5	—			256,500	
,,	13	6 p.m.	out	·73	45	48				262,400	
,,	14	9-30 a.m.	out	·63	43	46				277,600	
,,	14	6-30 p.m.	out	50	44-5	45				287,000	Still at 9 a.m. Bar. 29·61.
,,	15	11 a.m.	in	·63	44-5				197,500	293,400	
,,	15	6-30 p.m.	out	·66	43	43			188,500	293,500	
,,	16	9-30 a.m.	nil	·49	46	47				295,100	
,,	16	6-30 p.m.	nil	·51	49	49					Not moved.
,,	17	10 a.m.	nil	·62	52				199,100		
,,	17	6-30 p.m.	Suspecting something wrong, removed pressure gauge and found that the meter had ceased to register though there was a powerful current shown as soon as the pipe was opened.								

I may say that the meters were tested and stamped by the gas meter tester in London, and when unpacked in my presence at Solberge, they were in good working order.

I have rejected the results up to April 2nd as incomplete and imperfect. Taking the results from April 2nd, 1879, to April 6th, we have:—

No current, meters at rest at midnight on the 2nd and 3rd; barometer at 29·34.

Current exhausted on the 6th at 4-36 p.m.; and barometer at 29.08; fall of bar. 0.26.

Out-current observed in meter, 83,900 cubic feet; volume of cavity $= 83{,}900 \times \frac{29 \cdot 08}{0 \cdot 26} = 9 \cdot 984$ millions cubic feet; or ten millions of cubic feet nearly.

In the in-current from April 6th to 10th, the results are vitiated by the leakage observed from crevices round the stone-flags covering the well, and in the out-current following upon that the meter was thrown out of gear and ceased to register.

When this meter was taken down after returning it to Messrs. Glover, they informed me that the diaphragm and working parts of the meter were covered as with a dew from moisture condensed in the meter, showing that the out-current was saturated with aqueous vapour.

With reference to the probable position in the strata of the cavity, whose existence is the simplest explanation of these observations, it is, of course, more a geological question than a chemical one. I have, however, analysed the sandstone taken from the side of the fissure in the shaft, 15 yards below the surface. It will be observed that this sandstone contains about 7 per cent. of carbonates of lime and magnesia. So far, this fact suggests that the magnesian limestone which underlies this sandstone may at this point be at a comparatively limited distance below the

mouths of the fissures. At the nearest cutting near Northallerton it is found at a depth of about 400 feet.

The following is analysis of sandstone taken near the water level from the blowing well at Solberge, near Northallerton, April, 1880.

The stone, when fresh is soft and pliable. Strong hydrochloric acid applied to the stone disintegrates it with effervescence.

An analysis of the stone after partial drying by free exposure to the air gave the following numbers :—

Moisture	1·25 (by difference)	1·27
Silica	87·72	98·73
Peroxide of Iron (traces of Alumina)	3·96	
*Lime	3·58	
*Magnesia	0·32	
Carbonic Acid	3·15	
Sulphuric Acid	trace	
Loss	0·02	
	100·00	100·00

At the well at Langton Hall I have made only qualitative experiments. It is a disused well; the water being foul and unwholesome. On one occasion I visited this well there was a strong down current, readily shown by the smoke from a cigar, held at the crevices of the flags covering the well. On the second occasion when I visited Langton the current was in an opposite direction, blowing up a handkerchief spread over the loose joint of the flags. On this occasion I lowered a candle to the bottom of the well, and it burned clearly at the bottom. This circumstance when we remember that the well has not been in use or disturbed for years is important. The water from this well was exceedingly foul, and smelt offensively. On analysis it was found to be practically sewage.

These wells at Langton and Solberge are about five miles apart, situated on the rising ground separating the valleys of the

* These give 7·05 of Carbonates of Lime and Magnesia.

rivers Wiske and Swale. Whether the currents proceed from any common cavity I do not venture to say. I have thought of placing a large quantity of chlorine mixture or of free bromine in the disused well, and then sealing it up if possible so as not to leak during an out-current. Afterwards during such an out-current to test at Solberge for the free chlorine or bromine by means of iodide starch paper. The very large scale required for the experiment has hitherto deterred me from making it.

Finally, the well at Ornhams, Boroughbridge, I only know from description from Mr. Paver Crow, of Ornhams Hall.* It is the well supplying his residence, and the currents observed are very striking and powerful. A workman one day who had occasion to descend the well shaft compared the roar and noise of the air current passing into the crevices of the rock to that of the water in a mill-race. The gearing in use at this well prevents its being closed for the purpose of attempting to measure the current.

I have visited other wells in the neighbourhood of Solberge, and I have also analysed the waters. The latter are similar in character to that of the water from the blowing well, but no air currents exist. This fact bears on the idea that the currents may be due simply to the ramified fissures and porosity of the sandstone. The extreme and immediate sensitiveness of the current to the slightest change of the barometer also tends to prove this supposition.

The cavity is no doubt partly filled with water as indicated by the humidity of the out-current.

Both in the neighbourhood of Ripon on the south, and near Darlington on the north, where the magnesian limestone comes near to the surface, it is extensively cavernous, and in many places the thin beds of overlying strata and sandstone have given way.

In conclusion, I may suggest that similar phenomena no doubt occur elsewhere, and may be observed and reported now that

* The water I have analysed and found it similar to that at Solberge.

attention has been drawn to them.

In this paper it is shown—That these currents vary in nature and amount with the changes of the barometer just as the volume of the air in any closed receiver varies strictly with the atmospheric pressure when the influence of temperature has been eliminated. Hence the observations may be considered to prove the existence of large cavities or series of cavities or fissures in the underlying strata adjacent to the wells. In the case of the well at Solberge, this cavity has a capacity approximating to ten millions of cubic feet. A chamber 217 feet each way—length, width, and height, would have nearly the same capacity.

GLACIAL SECTIONS AT YORK, AND THEIR RELATION TO LATER DEPOSITS. BY J. EDMUND CLARK, B.A., B.Sc., ETC.

THE various deposits of boulder-clay, sands, gravels, brick-earths, warp and peat, near York, have been sufficiently exposed by building operations, brick fields, and gravel pits to show this very simple relation. Resting upon the deep-seated Triassic rocks lies the irregular boulder-clay, which forms all the higher ground, reaching in Severn's Mount to 100 feet above the river Ouse. Where the stream escapes from between its undulations, the topmost layers have been washed and re-arranged as glacial gravels. Its hollows have been levelled up with the sediment thus produced, forming the brick-earths and warpy clays; whilst peat deposits have completed the work where the depth, elevation, or remoteness of the original hollow prevented the brick-earths from accomplishing that end.

An examination of Plate XXIII., Fig. 1, will show the following relations.

The glacial beds form the chief feature of the region, not only monopolising all the ground more than about 30 feet above

the Ouse level (or 50 to 60 feet above that of the sea), but also forming extensive low-lands, except close by the river. Where these are sandy, and rest on clay, healthy commons still remain, such as Tilmire, Langwith, Strensall, and Riccall.

At present, unfortunately, there are no good sections in the glacial beds, but their character can be made out near the New Goods Station, at several points round the Mount, especially on Holgate Hill, and also at the Poppleton junction of the Harrogate and North lines, about two miles out. But, before discussing former exposures, it will be best briefly to indicate how the latter deposits are related to the boulder clay.

The chief gravel beds lie on either side of the Ouse, below the city. Brick-clays are worked by (1) a low, marshy spot called the Foss Islands; (2) west of Heworth road; (3) near the Poppleton Junction; and (4) on the S.E. edge of the large basin-shaped area called Hob-moor. The race course, Knavesmire, lying between the two glacial ridges separating Hob-moor from the Ouse, is also a brick-earth.

Peat deposits cover a large area at Askham bog and help to fill various small, elevated depressions, such as Campleshon pond D, on the Bishopthorpe Road, part of St. Paul's Square C, and a patch in Mr. James Backhouse's nursery gardens E; overlooking Hob-moor below Severn's Mount. The last two are concealed by Alluvial Deposits, which are about two feet thick at the nurseries. Yet here, at the peat surface when a fresh face is exposed, plants of the Water Violet, *Hottonia palustris*, not unfrequently spring up. The seed must have laid dormant for ages apparently, for not only is there no spot at hand whence it should come, but the position in its present state is too dry for favourable development. Bones of deer and fragments of a hollowed oak (perhaps a coffin or canoe) have been dug out from here. A canoe is possible, as there are indications that all Hob-moor may have formed a lake at one time. Such, certainly, was the part called Askham Bog at the opposite (S.) end, covering an area of $1\frac{1}{2}$ miles by $\frac{1}{4}$ to $\frac{1}{2}$

mile wide. The peat reaches a depth of 8 feet, and in wet weather the whole area is under water. The glacial ridge to the S.S.E. rises steeply above it, and must sink as steeply underneath. Probably the depth of the hollow, as well as its distance from the river, prevented the brick-earths from filling it up.

Two or three patches of peat also occur at the river level, perhaps indicating previous channels, like the bayons of the Mississippi. Both upon Clifton Ings and below Clementhorpe it is interesting to note that the river meadows sink away from the river, so that they are drained by small sluggish becks running parallel to the main stream. Another patch lies close by Ouse Bridge, under Brett's Brewery, the managers of which I have to thank for the following section obtained in their well :—

			Feet.	Inches.
	1.	Soft warp, with sand	27	0
	2.	Blue clay, (perhaps like the local brick clays)	10	0
	3.	Fine sand	12	0
	4.	*Soft bog*, and stone boulders	5	0
	5.	Dark yellow soft clay	6	0
	6.	Very loose gravel and pebbles, with water ...	2	0
	7.	Very fine sand	10	0
	8 & 9.	Not given	?	
Probably Triassic. Only 75 feet of pipes were driven.	10.	Soft brown free stone	12	6
	11.	Very soft and open gravel bed	3	6
	12.	Sample (sic), blue free stone	7	0
	13.	Soft blue and yellow clay, mixed	2	11
	14.	Brown free stone	5	10
	15.	Rock blue stone and soft sand	17	0
	16.	Brown iron stone, left off in stone	19	0
		Total (alluvial and glacial, perhaps 72 feet) . .	139	9

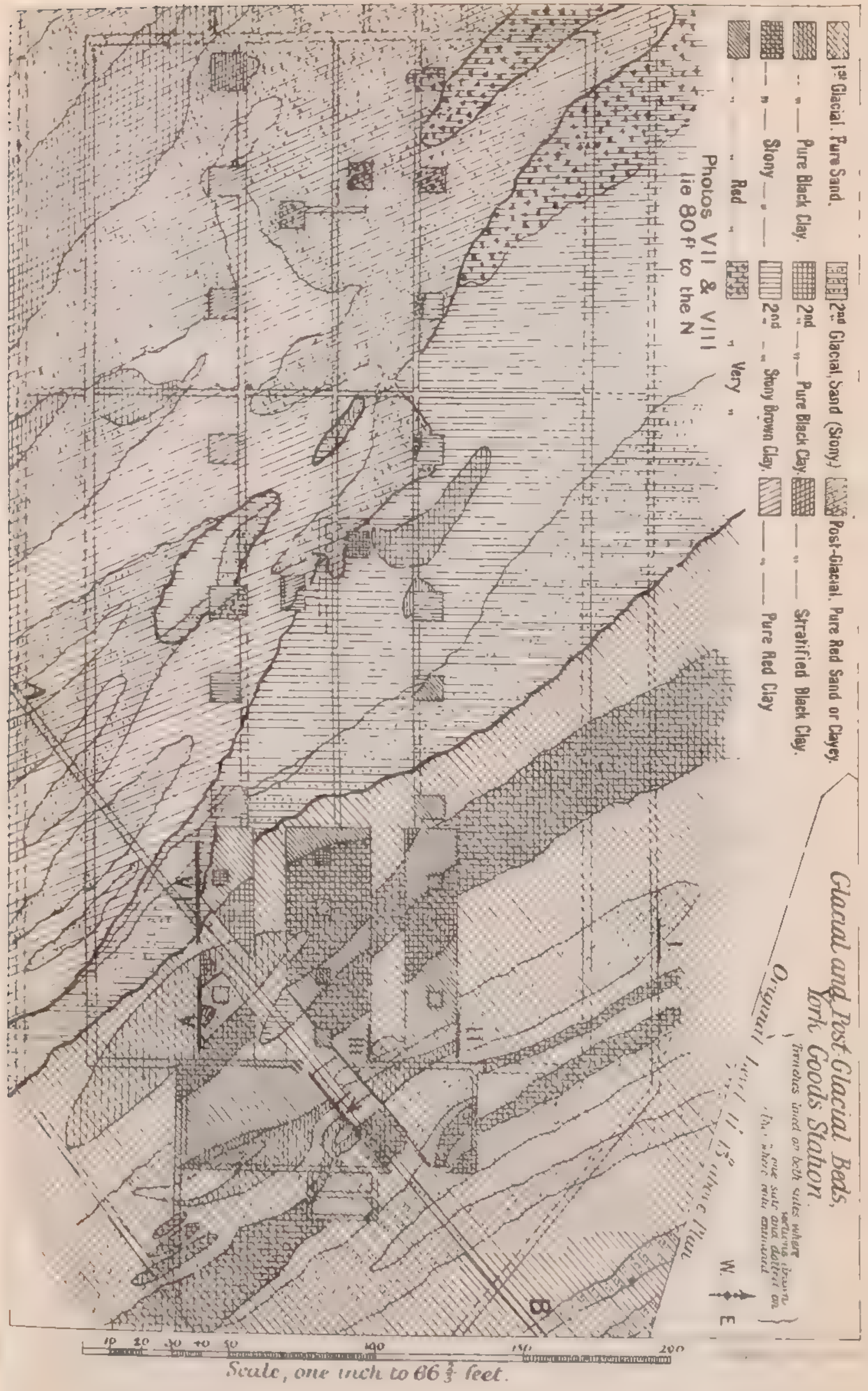
The River and Brick-earth beds, very remarkably, lie under 40 feet of sand and clay deposits, and have been regarded as inter-glacial, but I have not seen any adequate proof for such an inference. That the river deposits are in many parts very deep was well shown by the nine borings and excavations when the

new engine-house was erected at the Water Works. Warpy clays were first met, the dark clay being separated by sand so micaceous that it shone like silver; then came a dark clay full of plant roots to a depth of 20 feet, whilst even to 50 feet there was nothing of distinctly glacial origin. One of the borings, beginning 20 feet above the river's summer level, gave as follows:—

	Feet.
Clay, of various qualities, but always 2 feet of blue at the base	22
Sand (varying up to 15¼ feet at one boring) ...	8
Clay, free of stone	20
Sand	11
Loamy clay	2
Total ...	63

This great depth of apparently fluviatile deposit is striking from the close proximity of true boulder clays, which rise to the surface about 80 yards off. At this point it will be noticed the Ouse bends sharply where, comparing York mole-mills to mountains, it meets the outlying spur of Severn's mount, cut by the river at Clifton Scope.

A quarter of a mile to the north, at the Harrogate Junction, the railway enters a cutting 15 to 20 feet deep, where the glacial beds are still fairly exposed. They are sandy and gravelly, large boulders are scarce, but ice-scratched pebbles abound. The junction of the brick-clays with these beds occurs a yard or two S. of the signal box. It is, however, exceedingly obscure, even when best exposed. Just N. of the box the brick-clays rest on the sandy glacial beds, which are semistratified, dipping 1 in 8 or 9 to the S. Between the Harrogate and North line a large space has been cleared, leaving at the end a slope 200 feet long and 20 feet high, facing south. The east part had the same semistratified sandy clays—rearranged glacial beds—in which, at this point, no scratched pebbles were found. An irregular, nearly



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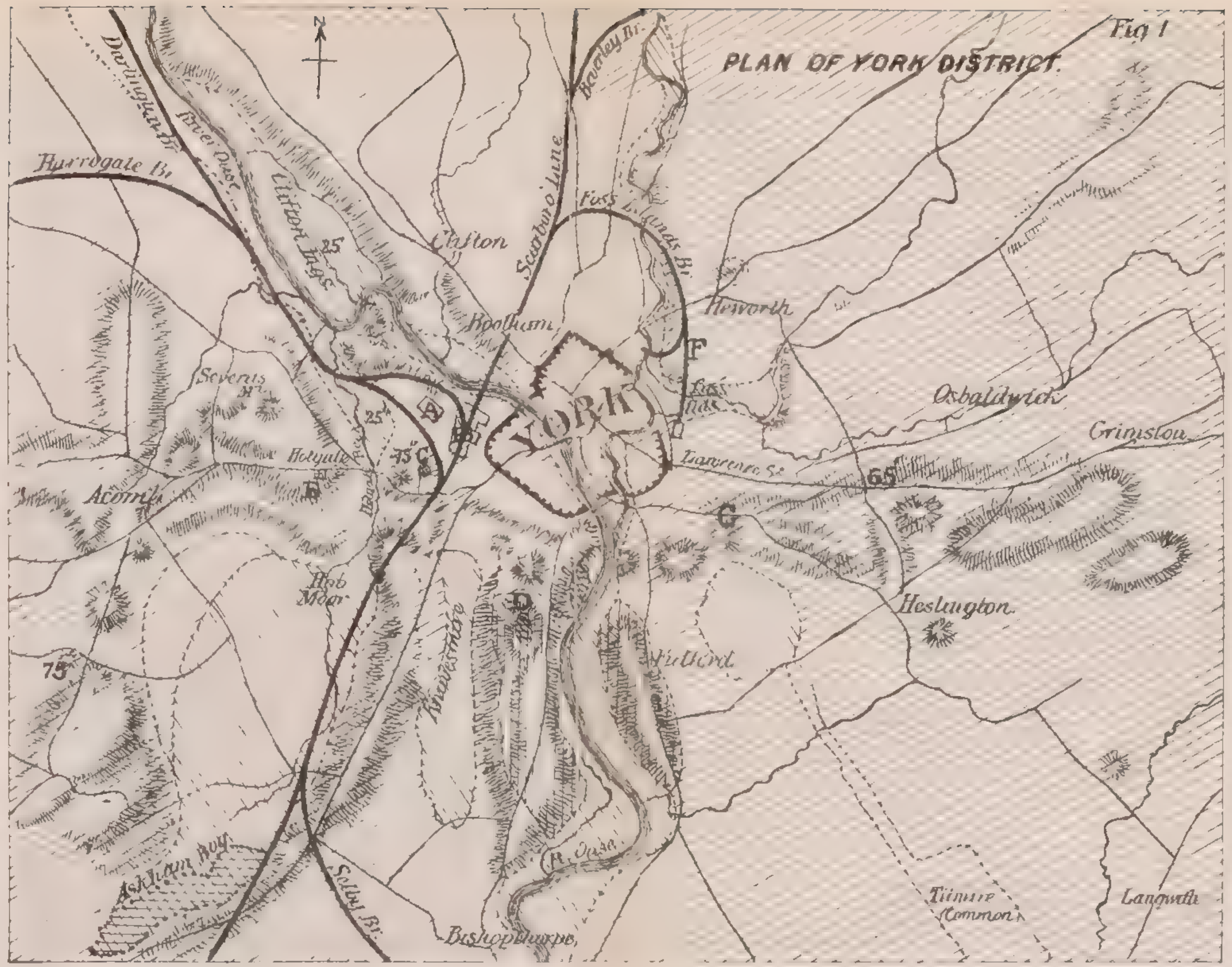

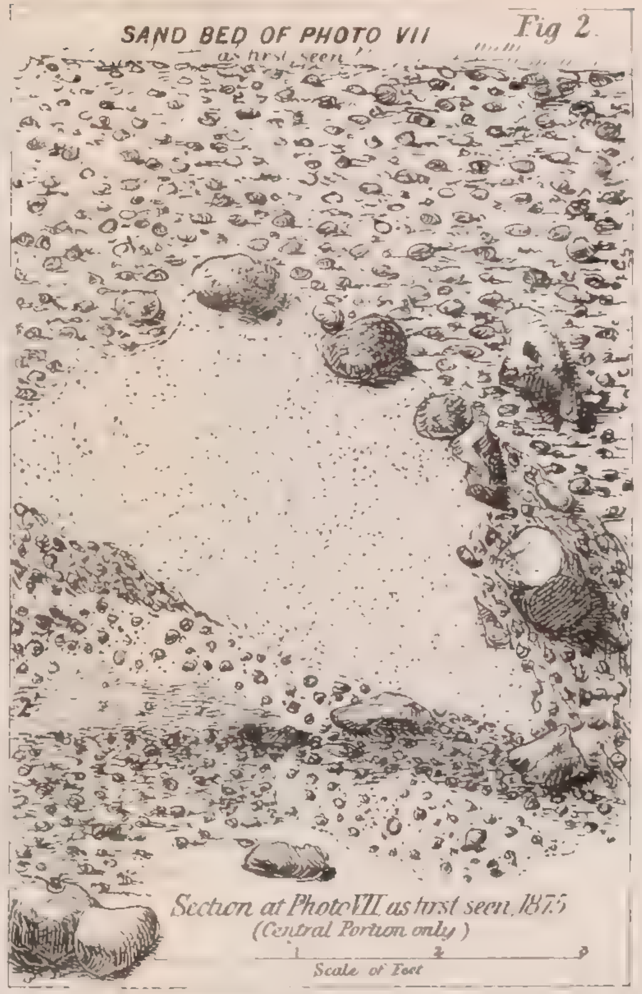

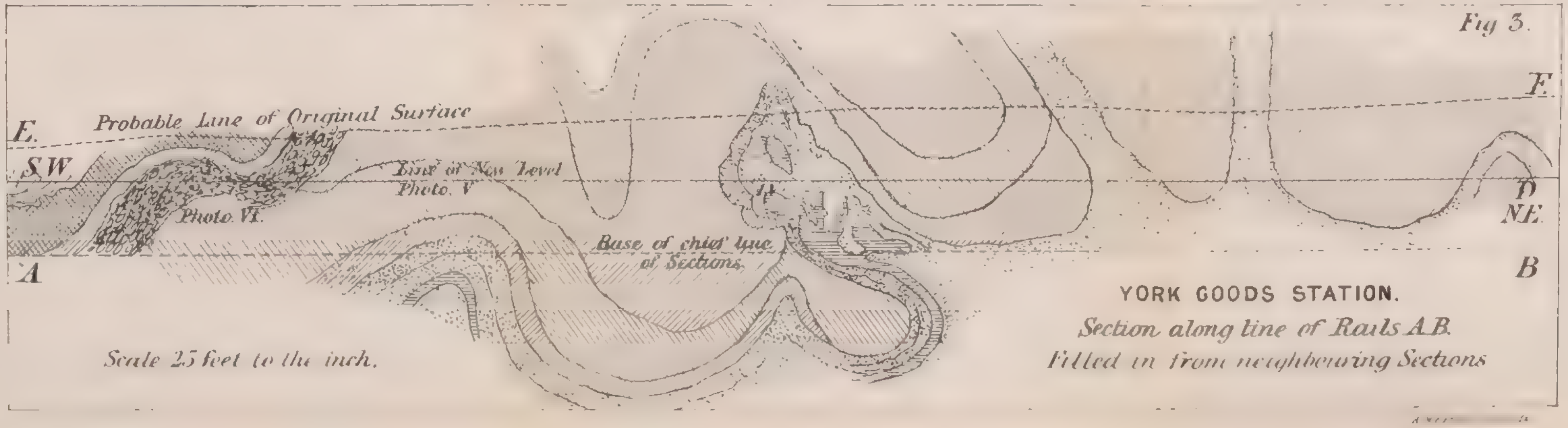

vertical, line separated this from beds of boulder clay, not so sandy and full of ice-scratched pebbles but containing some boulders.

The new Foss Islands branch of the N.E.R. exposed some interesting sections; and here, best of anywhere, was seen the junction of brick-earths and glacial beds. The Foss Islands are a marshy spot, where the stream of that name receives the Tang Hall Beck. So inaccessible was the city at this point that no artificial defence was ever erected. The peat and clay, where their surface is lowest, are 9 to 12 feet deep, resting on sands and gravels, probably glacial. These must be about 5 feet below the present Ouse level, or not 20 feet above the sea. The brick-clays, however, rise considerably at the sides of the beck, being 30 or 35 feet thick where worked on the south (Walmgate) side. Here they rise about 20 feet above the Marsh, as well as on the north (Laperthorp) side, (Plate XXIII., Fig. 1, F.), where the junction above mentioned was exposed by cuttings about 12 feet in depth. The stiff boulder clays had first been denuded by strong currents, leaving an irregular surface. This, at least in the part cut through, had been next covered with sand. Most of this, with the upper part of the boulder clay, appear next to have been planed away by some gentler denudation, and above the nearly level surface so produced, averaging seven feet above the rails, lay warpy brick-earths. Thus we get lenticular masses of sand, plano-convex in shape, lying between the two kinds of clay. Whilst the works were in progress the contrast between them was very great, the lower layer being left with a rough slope, whilst the upper was worked in a series of miniature terraces.

At places the boulder clays rose higher, even forming a tumulus-like boss east of the Heworth road. Great expectations were centred upon the cutting of this by our friends the antiquarians, who had its probable history already prepared. But the navigator's spade, relentless as fate, shattered these baseless fabrics in proving, once more, that even the slightest of York's little eminences may be due to glacial beds.

There must also have been corresponding depressions of the old surface; for brick fields W. of the Heworth road are worked to a depth of 20 feet or more. This is a good example of the levelling nature of the brick-clays, to which allusion has previously been made.

The largest boulder seen in this part was a block of sandstone, measuring $2\frac{1}{2} \times 2 \times 1\frac{1}{2}$ feet, containing about $3\frac{3}{4}$ cubic feet, and therefore weighing at least 500lb.

Gravels are worked, as has been said, on both banks of the river; their nature and position showing that they are rearranged glacial beds. The stones are identical, some of them retain their ice-marks, and the passage downwards into the true glacial beds is imperceptible. In the very midst of boulder clays (as in photo. VI,* for example) occur gravel beds which cannot be distinguished from these, both consisting of more or less irregular deposits of boulders, pebbles, gravels, grit, and layers of pure sand, the latter often very much false-bedded.

Gravel pits have long been worked between the road this side of Fulford new church and the river. They generally present a section 15 to 30 feet in height. The most peculiar feature is a bed of Manganese, 25 feet below the surface at the point worked in 1877. It was exposed at two positions 100 yards apart. The bed containing it consisted of loose dry pebbles, and was one foot thick. The upper five inches looked as if encrusted with soot (Manganese dioxide, $Mn. O_2$), whilst the pebbles beneath were brown with the sesqui-oxide, $Mn_2 O_3$. This also appeared in the bed above, as much as 5 feet being affected in places. Below this iron gave a corresponding ochreous coating, although the matrix was clayey. The workmen said they met the "soot" in all parts, although it occasionally thinned out. Samples of it, sifted to free from coarse sand, were analysed by Mr. T. H.

* See Plate ii., Fig. 3, left (S.W.) end. Copies of 8 Photos, cabinet size, may be had through the author. They are referred to and described later on.

Waller, B.Sc, of Birmingham, and myself, the results showing respectively 58 % and 61 % when all reduced to Manganese dioxide.

The following is one section of these variable beds :—

	Feet.
Surface soil, and red loamy clay	$6\frac{1}{2}$
Unbedded gravels, &c.	5
Horizontal beds of sand, clay, &c.	3
Loose gravels	$1\frac{1}{2}$
Layers of gravels, highly inclined	$4\frac{1}{2}$
Gravels, with Maganese Sesquioxide	2
Pebbles and gravels, encrusted with Manganese dioxide	$0\frac{1}{2}$
Pebbles, with Manganese Sesquioxide, then Orhreous	2
Total ...	25

The excavations do not reach the true boulder clays, and there are no signs of brick clays.

Crossing the river we have the corresponding, but rather more elevated beds along the Bishopthorpe road; and here, between Campleshon pond and Knavesmire, occurred a similarly situated bed of Manganese, with an Ochreous band below. There was also a second thin band among the ochre, about 4 feet from the first, which was about 10 feet below the surface. In a red and warpy clay, 4 feet above the Manganese, were some other black lines. But the Microscope showed that these were due to particles of coal dust and micaceous sand. Between the Manganese bands a few scratched stones were picked out, and one block had been removed measuring 2 × 2 × $1\frac{1}{2}$ feet.

These pits are now obliterated; but at fresh ones, a few hundred yards lower down the river, sections are constantly exposed. Here I had the good fortune to obtain a well preserved bone, identified as the metatarsal of *Ursus spelæus*, or the Grizzly Bear.* It was found by the workmen at the base of the bottom

* On the authority of W. Davies, Esq., of the British Museum, and Professor Boyd Daykins, Manchester.

gravel, here only 9 feet below the surface, resting on a sand bed, 5 feet thick. So far as I can learn this is the first instance of any carnivorous remains being found near York. The deposits at Overton, 5 miles to the north, only yielded Mammoth, Hippopotamus, &c. According to Phillips, the valley gravels have also produced *Cervus elephas*, *Bos primigenius*, *and Equus fossilis*; whilst recently a bone has been obtained by Mr. Keeping, believed to be that of the Rhinoceros.

Turning next to the glacial beds themselves, we will take up two series of sections which have thrown considerable light upon their local characteristics. The two special points to which attention should be directed are the mixed character of the beds and the marvellous contortions they have undergone.

During the spring of 1876, drainage works at the Friends' Retreat, York, made requisite some very deep excavations. These were accomplished by vertical shafts, connecting with a horizontal drift, at the deepest point 47 feet beneath the surface. The shafts were 50 feet apart, 10 feet wide along the drift, and 5 feet across. The whole excavation was in glacial beds, and had a total length of about 650 feet from N.W. by W. to S.E. by E., thus giving a transverse section of the hill.

Nothing unusual was noticed until the fifth shaft was begun. The first 25 feet of this was sunk in ordinary boulder clay. This was in all parts filled with pebbles and boulders, large mounds of which were heaped around. A block of sandstone measured 3 feet by $1\frac{1}{2}$ by 1 foot; its weight, therefore, must have been over a quarter of a ton. Just below sand-bed E,* however, between the 8th and 9th shafts, the workmen were much troubled by far larger blocks, one or two they thought, nearly a ton in weight. The limestone blocks were invariably scratched and polished, some of them presenting a magnificent appearance.

* The sand beds are called A, B, C, D. and E, beginning at the 1st shaft at the N.W. end.

The previous wet season naturally resulted in some trouble from water. The workmen, therefore, were not a little astonished to find dry clay in this shaft below 25 feet, becoming quite crumbly at 28 feet. Surprise quickly yielded to alarm as a stroke of the pick was followed by a violent *bubbling* in the water they were standing in. The men were hastily pulled out, nor would they venture down during the next four or five days; for all this time the bubbling continued. It was most violent at the S.W. corner, afterwards found to be the highest point of the succeeding bed. From careful enquiry it seemed to me that at least a cubic foot of gas was given off per minute, or 1500 cubic feet per day. But the amount might very well be several times as much; this is certainly a minimum estimate, yet it amounts to about 7000 feet. The space required must have been still greater; for sand grains occupy more than half the space they fill;* and the gas, as we shall see later on, could not have been subjected to more than twice the atmospheric pressure.

After the bubbling had ceased the sinking was continued, and the sand-bed (*c*) they had struck was found to reach the drift bottom. Here they found a clay-band, upon piercing which fresh bubbling occurred. They therefore stopped the hole and tried no further. Probably, however, all the air had escaped; perhaps a small amount had been detained in a fold of the clay-bed; for the water which bubbled up was mixed with sand.

This was the third sand-bed; the first (*a*) appeared in shaft I., 200 feet to the N.W. by W., 27 feet below the summit level at shaft VII., and 10 feet thick. Though the dip was S.E., towards shaft II. nothing was seen of it there or in the drift. In the latter, however, just beyond shaft II., was sand-bed B, dipping in the same direction, which was the reverse of bed C in shaft V. B began in the roof of the drift 10 or 12 feet from shaft II., and stretched 23 feet along it. On the floor it began about 12 feet

* A fine grained sand was found to remove more than three-fifths of the water contained in a vessel.

further on, and reached to the base of shaft III. These facts were told me by the foreman, as the shafts at my first visit were already filled in; but the remaining heaps of sand, clay, and boulders verified his statements satisfactorily.

Shaft VI. when first seen was sunk to 27 feet entirely in boulder clay. The drift, four feet high and about three wide, was driven half way towards it, and showed sand-bed B to a distance of 10 feet in the floor and 21 feet in the roof; whilst two or three feet beyond was a thin bed of gravel in what otherwise looked like ordinary boulder clay. The dip of the upper surface of the bed was the same, but more inclined, as shown in the shaft. The men had met it in the drift about 8 feet on in the roof, thus giving 39 feet in all for the horizontal direction, which shows a thickness at this part of 15 feet. The section indicates, however, that the bed is wedge-shaped, thinning out below.

The completion of shaft VI. showed that this sand-bed was not continued far upwards, for the dip of the lower surface would have intersected the shaft about 35 feet from the top. Shaft VII. contained much sandy gravel in boulder clay so far as sunk; but the rush of water at 23 feet (24 feet above the drift floor) led to its abandonment. In shafts VIII. and IX. two new sand-beds (D and E) were met. D near the top appeared to lie in a hollow, the sections in the two shafts dipping towards each other. E was more than 40 feet down, partly in the drift; it was three feet thick, of red clay-seamed sand, a foot lower in shaft VIII. than IX.

Nothing but very stony boulder clay was seen until shaft XII., 550 feet from the beginning and 350 feet from the bubbling shaft. Here there was a thin sand-bed (F) of six inches, about half way up the shaft. The next shaft, however, was entirely filled with sand below a foot of soil; and the same was true of shafts XIV. and XV., which were only 12 or 15 feet deep and close together.

The only further point of importance was the finding of masses of coal; a rolled lump being brought up from shaft III.

30 feet down, and an angular fragment from a depth of 15 feet in shaft VI. Pieces of these I saw myself. Bits of so-called jet, probably lignite, were reported just above sand-bed E, or 40 feet from the surface.

The chief interest of the sand-beds here disclosed lies in their discontinuity and the probable cause of the mysterious "bubbling." Confining our attention to the 400 feet between shafts I. and IX., we have five *distinct* sand-beds ; for had any two been connected they must have been met again in the shafts or level drift. Beds B and C are the only exception, and at first I thought they might join below the drift. The pressure, however, producing the "blower" in shaft V. when C was first tapped, would certainly have disappeared had the bed joined B, which was laid bare not 150 feet off. But not only must the five sand-beds be distinct from each other ; so also must the bed struck in shaft VII. from beds met in VI. or VIII., for otherwise such a rush of water, when nothing noticeable happened 50 feet on either side, is impossible. These glacial beds must therefore consist of irregular deposits,—a series of false beddings upon a large scale. And yet true boulder clays, and scratched and polished boulders are as abundant as in glacial deposit in the neighbourhood.

This fact gains added interest when the situation of the Friends' Retreat is considered. It lies half-a-mile E. of the Ouse, on the continuous ridge stretching in a large crescent from near the Ouse, below the junction with the Foss, to Sand Hutton, N.E. of York, a distance of 8 miles. In most parts it is marked by a steep slope on the convex side, which faces S. and averages about 50 feet above the levels, which are 30 to 40 feet above the sea. The height a few yards W. of these sections is 100 feet, and 119 feet where the Stamford Bridge road crosses the ridge at Holtby.

Again, almost in a line with it and with the same general direction, is the ridge to the W. of the Ouse, along which the great south road runs as far as Bilborough, 6 miles to the S.W. Here it rises considerably above 100 feet, and is also crescent

shaped, but facing more easterly. The whole length of 14 miles naturally suggests the Scotch Eskers. There are, moreover, other elevations parallel to it. On the west bank we have the gravel-capped ridge stretching to Bishopthorpe, and the broken line from the new water works, one mile above York, through Acomb and Askham Bryan to Askham Richard. In the two last districts, however, it is little but a capping on the Triassic beds; and near the Ouse all three ridges are lost in the irregular series of elevations parallel to the river.

Turning to the other point,—the remarkable bubbling,—the following is, perhaps, the most probable explanation. As we have seen, the sand-beds are very disconnected, and bed C especially, was evidently cut off upwards. Shaft V. seems to have tapped it near its highest point. It was covered by thick impervious boulder clays. Their impenetrability in most parts was indicated by the yard of remarkable dry, crumbly clay above the sand. The wet from above could not descend as fast as the air forced in from below absorbed the moisture. Probably the sand-bed was like a closed cistern, with entrance and exit apertures low down, the former being the more commodious. In dry seasons, however, the exit would drain off the water collected in the sand-beds, and this water would be replaced by air. In wet seasons—such as the winter and spring of 1876—water would collect faster than the exit could remove it; or perhaps the line of saturation might rise above the point where both entrance and exit apertures lay. In either case the air in the sand-bed above, having no means of escape, is subjected to pressure by the rising water, the amount depending upon the height of the line of saturation at the water level in the sand-bed. Under this pressure the air slowly forced its way up through the superincumbent clays, which thus grew dry and crumbly. When the sand was tapped near the summit of the bed at shaft V., this air was blown out from the sand by the rising water, with a pressure, probably, of several pounds to the square inch. For the line of saturation was at the time at least

10 or 15 feet higher than the sand-bed, since the water which covered the shaft bottom trickled in freely at 15 or 20 feet from the surface. Excepting deductions for friction, this would produce a pressure of half an atmosphere, so that the confined air would occupy a space about $\frac{2}{3}$ of that required under ordinary circumstances. On the eastern side there is a parallel ridge, beginning nearly opposite the junction of the Wharfe and Ouse to a little south of Stamford Bridge.

The second series of sections were exposed in connexion with the extensive levellings and excavations for the new Goods Station. These were begun in 1872 and continued until 1878, but unfortunately there is no record for the greater part of the work. Returning to York in August, 1875, the last half-acre only of the beds to be removed from the site were left, and these, also, were gone before I had leisure to examine them. They were very gravelly in parts, but sand-beds were not conspicuous. Altogether from 3 to 13 feet of "ballast" was removed from an area of 4 acres. The part actually examined was the area below this, so far as it was disclosed by sections reaching at points to 14 feet deeper down, or a total depth of about 25 feet. These were uncovered in erecting the present Goods Station, and occupied an area of about $2\frac{1}{2}$ acres (See Fig. IV). The N.E. boundary of the levelled area, with excavations for engine-sheds and various road approaches, added some interesting details. But the chief part is this levelled area, whose surface lies, as stated, from 3 to 12 feet below the original meadows.

The Goods Station itself is a rectangular building of about 120 yards by 60 yards, with an annex at the east end for offices, as shewn by the plan. Beneath this annex, and also for 78 feet from it, under the three platforms, the ground was excavated for cellars to a depth of 7 and $7\frac{1}{2}$ feet. Further holes, some 7 feet deep, were made at the bottom of these. Over the rest of the area, shallow drains, pits, foundation trenches, and a drainage trench 6 feet deep, 16 feet from the building, gave disjointed, but

fairly satisfactory evidence of the beds contained in the area. These beds could not be followed on the surface, which for most of the winter was 6 or 8 inches deep in clay mud.

From these data the above named plan has been drawn up to indicate the various beds. There are yellow glacial sands (1 and 5); red (or purple) and black boulder clays (3 and 4, 7 and 8); a pure, black glacial clay (2 and 6); pebble beds, red alluvial sands (9); red and black laminated clays (10 and 11). Sections at greater depth are indicated by deeper shade. Altogether the mixture of substances, and the regular strike of the beds (as if pressed by some enormous mass, moving up from the S.W.) makes the whole area one of singular interest. Of these beds, the red sands and laminated clays in the S.W. part are post-glacial, forming a thin skin, beneath which the trenches frequently show the glacial beds. The S.W. corner is nearest the original level, perhaps only 3 feet below it, whilst the N.E. corner and, indeed, a full third of the area, must have been 12 feet below.

Turning, however, to the *vertical* sections, especially as disclosed in the cellars, the interesting character of the beds is more obvious. The same beds are cut across again and again by the parallel sections. Their rise and fall and mutual relations are easily followed. In the case of a sand-bed, (Pl. XXIII., Fig 3) it appears as if its convolutions were intersected two or three times, from 1 to 6 sections of each fold having been exposed, All these beds lean towards what may be termed the central axis of the system.* Of this we have the first sign in a flat dome of black clay under red clay on the S. wall of the N. platform-cellar, still better seen on the N. side of the mid platform-cellar, where it is 21 feet long and 2½ feet high. Proceeding S.E., along the strike, we meet it again on the S. side, the cellar being 28 feet wide. The dome of black clay is now cut off above, where it is 9 feet broad, the base having increased to 36 feet. Beneath it there now appears a second dome of pure yellow sand, which is first seen at

* This can be easily picked out running N.W. from the S.E. corner of Plate I.

one of the centre pits, $7\frac{1}{2}$ feet below the ground level. Six inches from its upper edge is a band of black clay. The bed is highest on the S. side of the S. platform-cellar, where its appearance is shown by Photo. V (Plate XXIII., Fig. 3).

The black boulder clay, it will be noticed, arches more steeply on the E. than on the W. side. At the base a second, and thick band of the same pure black clay is exposed, as well as in the horizontal section along the floor. After this the sand begins to sink again, being met at a lower level in the next section, the purple clays again closing over the black.

In the N. and mid platform-cellars, a second bed of boulder clay rested against this red, but disappeared at the surface before the S. platform-cellar, so that the succeeding bed of purple boulder clay met the first, the two, however, thinning out slightly as they proceeded across the S. platform-cellar and large cellar. In the S.E. corner of the latter appeared black clay, purple clay, both with boulders and sand, the first two being reversed on the other side of the sand and thining out rapidly above. Thus the sand is united to the next bed of sand, of which, indeed, it was only a contortion. For this succeeding bed was a series of remarkably contorted sands, the twists being shown by lines and masses of the same unctuous, black clay seen in Photo. V. Where first seen at its N.W. end in the N. drainage trench it presented a dome of sand leaning over towards what we have called the central axis of Photo. V. Its varied character is shown in Photos. I. to IV. I. is from the N. side of the N. foundation trench. Here the top of the dome has already risen above the levelled surface. A large scratched limestone boulder lies in the purple clay above it. In Photo. IV. the bed is seen at its best. Here, especially, micaceous lines and lines of grit help to show the contortions; elsewhere there are also lines of coal dust. In the cellar floors the sands occupy a much larger area. The disjointed pieces of black clay, specially well show at Photo. IV., must have formed a continuous band. Further beds of sand and red clay

succeed to the N.E.; but here the sections were much more obscure. It seemed, however, pretty certain that they represented two more folds of the same beds.

Photo. IV is upon a line of rails crossing the cellars from N.E. to S.W., and therefore about at right angles to the line of strike. Combining our various sections into one along its face they would give the actual appearance and probable connexion of the beds shown in Plate XXIII., Fig. 3.

It will be noticed that S.W. of the central axis the beds are inclined the other way, or a second time against that bed. We need only call special attention to the layers of boulders, gravels, and sands, shown in Photo. VI. This bed was traceable quite across the area, the extreme sections in it being 100 yards apart.

West of this come a few more boulder clays, after which the surface is occupied by post-glacial beds, as already said. In parts the two were hard to distinguish, but elsewhere the laminated upper clays contrasted strongly with the tough boulder clay, and here and there the surfaces were irregular at the junction, especially near the pits, cutting the line of junction.

Turning, now, to the N. boundary, the beds differ considerably. The difference is not great at the east end, where the bank is only 25 feet from the drainage trench. Here the beds are not distinctly connected with those of the lower level.

The northerly trend takes the bank 200 feet off at the W. end of the Goods Station. About half-way is a recess, 120 feet across, and 25 feet deep to the east, 80 to the west. The beds round this are very much twisted, as was shown for the W. side by Photo. VIII. A pile of round stones, the largest to the N., looking as if shot off an ice-berg, and a clay-line proceeding N. from it with twisted beds above and below are most noticeable. Beyond this, running at an average depth of 4 feet, but sometimes much lower, is a nearly continuous bed of pebbles and boulders of all kinds. 38 feet from the corner, (Photo. VII., Plate XXIII.,

Fig. 2) it is remarkably broken. There is a central mass of pure sand, quite angular in shape when first seen. On the E. side rest stones at a steep angle. Exposure had sadly reduced the angularity before the photograph could be taken, and now the mass, which barely penetrated a foot into the bank, has gone. To all appearances it had fallen as a solid, frozen lump; for the nature of the surrounding beds indicate depositon from above as their source.

Several other most interesting sections were made in the neighbourhood, the most important being a long line of contorted beds, dislosed at the rear of the Passenger Station (Plate XXIII., Fig. 1, B). Near the N.E. end were gravel beds like those of Photo. VI., apparently among the boulder clays. They included sands excessively false bedded, a condition which occurred again further on. Thirteen beds were counted in a space of 3 feet by 1½ feet. A section taken at another point shows 14 sets in a rectangle of three feet by two.

Space forbids more than the barest mention of the stones brought together, even on the small area of the Goods Station. Shap granite, though ubiquitous, is not abundant. Lake stone (a volcanite breccia), slate, and basalts must be *voyageurs* from a distance; but of course the Carboniferous beds from the West Riding supply the greater number. Indeed, these beds form in consequence a successful hunting ground for the young geologists of the Friends' School, to some of whom I am indebted for polished corals, encrinites, and agate.

All these have drifted from the west, but from every spot mentioned evidence has been forthcoming, from the presence of Liassic Grypheas and various fossils of the Inferior Oolite, that the stream, at times, was reversed, pouring upon the plain of York contributions from its eastern margin. As yet in *no* case have chalk fossils been detected; hence any drift from the east appears to have a southerly set. South of York, according to Professor Phillips, the glacial beds frequently include Cretaceous remains.

Few boulders, except the limestone and lake-stones, retain the scratches. The former, when freshly removed, often had a beautiful polish, soon lost on exposure, a large mass, in my possession, weighing 42 pounds, shows as well the original surface with spar, and glacial fracture.

The glacial beds here described most resemble the Purple Boulder Clays of Messrs. Searles V. Wood and Harmer. Their appearance, however, indicates a deposition from floating ice, rather than, or as well as from the *moraine profonde* of an ice-sheet. Otherwise it would be hard to account for beds of gravels, boulders, and current-bedded sands so closely associated with the tough stony clays. Judging from the material, the ice-sheet or floes must have come chiefly from the N.W.; though even in the boulder clay specimens occur showing drift from the E. or N.E.

There are many indications of a division into *two* glacial periods, the second much less severe than the first. To it might be assigned:—(1) the upper eastern deposits at the Poppleton Junction; (2) the lenticular sand masses in the Heworth part of the Foss Islands Railway; (3) Sand-beds D and E, and parts above, and to the S. of E in the Retreat section; (4) the gravel bed of Photo. VI., and the bed to the S.W. of it in the plan of the new Goods Station area; (5) the beds above the line shown in Photo. VIII., and continued on to the W.; (6) the gravels, boulders and false-bedded sands in the upper part of the section behind the Passenger Station.

Post-glacial beds, probably derived very directly from the glacial of the district, have been formed to a considerable depth. Brick-clays as well as gravel beds are worked for 30 feet or more. The river deposits seem to go much deeper, and the peat bed at Brett's brewery may be as easily explained if post glacial as if we call it interglacial. The beds above it partake more of the latter aspect.

The Ouse as was pointed out many years ago, is 60 or 70 feet above its preglacial bed. The slight protrusions from the

general dead level are of glacial origin; whilst the river flood and tidal deposits have largely obliterated these undulations by filling them up, perhaps as much as 50 feet above the level to which the river first cut down its bed in the opening of the post-glacial epoch.

EXPLANATION OF PLATE XXIII., FIG. 1.

SUPERFICIAL DEPOSITS ROUND YORK.

Laid down on the one inch map of the Ordnance Survey from notes and plans.

A. New Goods Station.
B. New Passenger Station.
C. St. Paul's Square.
D. Campleshon Pond.
E. Holdgate Nurseries.
F. Cuttings on Foss Islands Railway.
G. Friends' Retreat.

ASTROMYELON AND ITS AFFINITIES. BY JAS. SPENCER.

THIS new genus of fossil plants was first described and introduced to the scientific world so recently as the year 1878, by Professor W. C. Williamson, F.R.S., in his ninth memoir "On the Organization of the Fossil Plants of the Coal Measures." Fragments of Astromyelon, however had been previously found and described as Calamitean, on account of their close resemblance to similar structures in Calamites, both by Mr. Binney and Professor Williamson. Since the publication of the above memoir, our knowledge of this interesting genus has been largely increased by the discovery of a large series of additional specimens by myself and other workers in this branch of science. I purpose in this paper to give a short sketch of what is known about Astromyelon and also of its nearest relations.

The Astromyelons have been named and described solely from the microscopical examination of specimens obtained from

the coal-balls found in the Halifax Hard Bed Coal, and in a similar coal in the neighbourhood of Oldham. Very little is known respecting the external appearance, but they appear to have been for the most part small herbaceous plants, like Asterophyllites and the smaller kinds of Calamites.

I have recently found specimens of Astromyelon both as casts in sandstone and as impressions on shale. In the flagstone quarries at Ringby, near Halifax, I saw the impression of a longitudinal section of the stem of Astromyelon on the face of a flagstone, which shewed the structure almost as perfectly as a coal ball section. The mural arrangement of the cells of the medulla—so familiar in examples from the coal-balls—presented the appearance of a wall of white bricks, while the basement layer and copings were represented by the narrower, and darker, and more compact layers of the ligneous zone. The fragment was impressed on a filmy layer of micaceous shale and broke into smaller fragments when I attempted to secure it. It is evident from this fact, that the remains of this plant must either have been overlooked or else confounded with those of other fossil plants.

The coal-ball material in the neighbourhood of Halifax has yielded a variety of Astromyelons, and many of them in a beautiful state of preservation. The transverse section of a perfect stem of a typical specimen shews a central parenchymatous medulla, surrounded by a woody cylinder, which is composed of a regular series of primary wedges. These wedges are almost identical in structure with those of Calamites, with the exception that the canals at the inner ends of the wedges are absent; the wedges are also more obtuse than those of Calamites. The number of wedges forming the exoginous cylinder varies from five or six in very young specimens, to from nine to thirteen in more mature ones. In Calamites the wedges are more regular and smaller in size, and range from eleven to sixty or more in number, according to the size of the plant.

In Astromyelon the woody wedges differ considerably in size,

sometimes even in the same plant; each wedge is composed of a number of laminæ which are arranged in a radiating manner, and each lamina is again composed of a number of vessels which increase somewhat in size from the apex of the wedge outwards. In young specimens, the vessels are larger and more various in size and form than in more mature forms. In older stems the vessels are smaller, and the exoginous zone is more firmly knit together by the growth of new cells among the older ones in a regular exoginous manner. The central medulla forms a solid pith, the cells generally largest in the centre, but become smaller as they approach the woody wedges and fill up the spaces between them, and being thin walled they give a light appearance to the pith, forming a strong contrast to the darker wedges of the ligneous zone, causing the "star-like" appearance from which the plant derives its name, "Astromyelon."

Astromyelon differs also from Calamites in its mode of branching. It has branches like those of ordinary forest trees, while in Calamites the branches were articulated to the stem, and had their origin solely in the thick bark. In the longitudinal sections of the two plants the pith is seen to be fistular in Calamites, with only a thin lining enveloping the inner ends of the woody wedges, whereas it forms a solid structure in Astromyelon; the pith also extends to the branches which is not the case in Calamites. The structure of the pith is different in the two plants: in Calamites it partakes more of the character of cellular parenchyma, but in Astromyelon it is composed of oblong cells which form an intermediate stage between cellular tissue or parenchyma, and the higher stage of vessel structure, termed prosenchyma, the term used to indicate this higher stage of cell structure is *parenchymatous.* This mural parenchyma has been noticed by Professor Williamson as forming a conspicuous feature in many of the fossil cryptogamic plants.

In coal-balls two varieties of Astromyelon are found, namely, the normal one with the large star-like pith, and another in which

the pith is absent. There is such a striking difference between the two extreme forms, that were it not that a large series of specimens shew a complete gradation between them, they might be considered as separate species; some specimens have the woody wedges clearly formed but the pith has disappeared; other specimens shew a continuous cylinder without even a trace of wedges and a hollow space in the centre.

In my paper on "Astromyelon and its Root," which I read before the Geological Section of the British Association at York, I described two new forms of Amyeloid Roots, which I believe are the roots of Astromyelon. It must be premised however that they have not been discovered connected with the plant.

The new specimens in my collection belong to the class of pithless roots which Professor Williamson has described under the name of "Amyelon."

One of these *Amyelon radicans* is regarded as one of the roots of Asterophyllites; it bears the closest resemblance to the new specimens and it may be advisable to give a short description of it. Amyelon radicans has a solid vascular axis, formed of comparitively large vessels, which are plain on their tangential faces and reticulated on their radial faces; the bark is rarely preserved, but when a portion is met with it is seen to be of rather loose texture. The most characteristic feature of this plant is the beautiful reticulations on the cells. The cells in the stem of Asterophyllites are also beautifully reticulated, and it was from the peculiar character of these reticulations and their being confined to the radial faces of the vessels, that is to the sides of the vessels facing the medullary rays in each plant, that their affinities were established.

I have already pointed out that under the name of Astromelon a very widely divergent group of plants are comprehended, which may be necessary to be divided into two or more species. The common form with the star-like pith forms one group, while those with little or no pith may form another. The root which I

have named—*Amyelon radiatus*—most probably belongs to the former while the other is more allied to the latter group.

It has already been pointed out that the woody cylinder of Astromyelon bears a resemblance to that of Calamites. I wish now to draw attention to the woody cylinder of Asterophyllites. It was regarded by some authorities as the leaves and young branches of Calamites, along with Sphenophyllum and Annularia; but the discovery of its stems in a good state of preservation has shewn that Asterophyllites is an independent plant. In the French coal fields Sphenopyllum has also been found preserved in a similar way, and its structure closely resembles that of Asterophyllites; but hitherto neither Sphenophyllum nor Annularia have been recognized in sections from the coal-balls.

Transverse sections of Calamites and Asterophyllites shew how widely they differ from each other: in Calamites the woody cylinder is formed of an indefinite number of wedge shaped masses, varying from eleven to sixty, according to the size of the stem, whereas in Asterophyllites there are always three large wedges in the young and old alike.

Again, the pith in Calamites is confined to a narrow zone surrounding the woody wedges, the centre of the plant being hollow, as it is in the modern horse tails, whereas, the centre of the stem in Asterophyllites is occupied by a remarkably characteristic pith, triangular in section and composed of vascular tissues; from each of these three angles extends a woody wedge, which in very young stems are small in size, and the spaces between them filled with parenchymatous tissues, but in older forms they increase in size until they form a solid cylinder. In all other respects the character of the wedges is the same as those of Calamites and Astromyelon. The structure of the bark which is generally preserved is also different from either that of Calamites or Astromyelon.

From this brief account of Astromyelon and its allies, it will be seen that in one of the most important structures—the ligneous

zone—there is a remarkable agreement in the form of the wedges and in the vessels and cells composing them.

In conclusion, the position which this most interesting group of plants occupied among the coal measure plants may be indicated—the Astromyelon and its allies seem to have occupied an intermediate position between the Lepidodendroid plants and the Gymnosperm Dadoxylons. The ligneous zone in the former plants closely corres ponds to the woody cylinder of Dadoxylon, while their parenchymatous tissues are homolegous with similar tissues in the Lepidodendroid plants.

ON A DISCOVERY OF FOSSIL FISHES IN THE NEW RED SANDSTONE OF NOTTINGHAM. BY ED. WILSON, F.G.S.

Reference.—Report, British Association for 1881.

SECRETARY'S REPORT.

During the current year three meetings will have been held. On April 27th the Members met at Hull, in the Lecture Theatre of the Royal Institution. The chair was occupied by A. K. Rollit, Esq., L.L.D., D.C.L., F.R.A.S., F.L.S., etc., President of the Hull Literary and Philosophical Society. After the meeting the members, accompanied by the Hull Student's Association and the Geological Section of the Literary and Philosophical Society, proceeded by special train to Withernsea; Prof. James Geikie, F.R.S., accompanied the party and gave a description of the glacial clays, &c., forming the coast line.

The fiftieth anniversary of the first meeting of the British Association at York has been commemorated this year in the city which gave it birth, and your council considered that it would be advisable to postpone a second meeting until after that of the Association. The present meeting is, therefore the second one for the present year, and a third will be held in November next, at which papers will be read which could not be included in the already lengthy list before us. The Society is indebted to Dr. Rollit and Mr. Wilson, of Hull, the latter of whom has been good enough to accept the office of Local Secretary for that city, and to Mr. Tate, the Local Secretary of Bradford, for their kind and ready assistance in making arrangements for the respective meetings; and also to the Council of the Hull Literary and Philosophical Society, and to the Governors of the Grammar School at Bradford for the use of their rooms.

There has been an addition during the past year of twelve new members, the total number now standing at 207 of whom 19 are life members and 188 ordinary members.

The Society has lost by death two members, viz.: Fairless Barber, F.S.A., &c., of Rastrick, and J. Fraser, C.E., &c., of Leeds. Both gentlemen were well known in the county and far

beyond its borders. The former in connection with the Yorkshire Archælogical Society, of which he was honorary secretary and editor of its Proceedings, as well as the author of several small works on local Archeology. The latter from his practical engineering knowledge, frequently brought to bear in the construction of works in the county and elsewhere.

The following is a list of the Local Secretaries and the places which they represent.

Barnsley	Thos. Lister.
Bradford	Thos. Tate, F.G.S.
Bridlington	G. W. Lamplugh, F.G.S.
Brighouse	T. W. Helliwell.
Driffield	Rev. E. M. Cole, M.A., F.G.S., &c.
Halifax	W. Cash, F.G.S.
Huddersfield	Peace Sykes.
Hull	G. J. Wilson, M.A., &c.
Leeds	J. E. Bedford.
Mexbro'	Rowland Gascoigne, F.G.S.
Middlesbrough	Dr. W. Y. Veitch.
Ripon	Rev. J. S. Tute, M.A.
Selby	J. T. Atkinson, F.G.S.
Sowerby Bridge	J. Marshall.
Thirsk	Ed. Gregson.
Wensleydale	Wm. Horne.
York	Rev. Thos. Adams, M.A., F.G.S.

Proceedings, forwarded from their respective Societies, in exchange for those of our Society, have been received and may be consulted by applying to the Hon. Secretary or at the Museum of the Literary and Philosophical Society at Halifax. The following is an enumeration of them :—

List of Societies whose Proceedings are forwarded to the Yorkshire Geological and Polytechnic Society:—

Yorkshire Archæological and Topographical Society.
Warwickshire Natural History and Archæological Society.
Royal Society of Tasmania.
Royal Dublin Society.
Royal Historical and Archæological Association of Ireland.

Geologists' Association.
Manchester Geological Society.
Literary and Philosophical Society, Liverpool.
Royal Institution of Cornwall.
Royal Geological Society of Ireland.
United States Geological Survey of the Territories.
Boston Society of Natural History.
Hull Literary and Philosophical Society.
Connecticut Academy of Arts and Sciences.
Academy of Science, St. Louis.
Historical Society of Lancashire and Cheshire.
Geological Society of London.
Royal University of Norway.
Sociètè-Geologique du Nord.
Oversigt over det Kongelige Danske Videnskabernes Selskabs, Kjopenhavn.
Museum of Comparative Zoology, Cambridge, U.S.A.
Watford Natural History Society and Hertfordshire Field Club.

Copies of the Proceedings of the Society for the following years may be had on application to the Honorary Secretary, Chevinedge, Halifax, price 2s. 6d. each:—1840, 1841, 1842, 1843, 1844-5, 1845-6, 1847, 1848, 1851, 1853, 1854-5, 1858-9, 1860, 1862, 1864-5, 1865-6, 1867, 1868, 1869, 1870, 1871, 1875, 1876, 1877, 1878, 1879, 1880.

It has been inconvenient during the present year to continue the work of exploring the Raygill Fissure, on account of the quarrying operations in its immediate vicinity. The latter however will prove of material assistance in the future work of the committee, by enabling them to gain an easier access to the Fissure and so reduce the cost of working considerably. A report of the work done last year was read at the meeting of the British Association at York, and a grant of £20 was made to the committee to assist them in the future investigation of the Fissure.

The council would also express their thanks to W. H. Dalton, Esq., of H.M. Geol. Survey, for his kind and valuable assistance in the preparation of the Bibliographical lists, which from year to year form a very valuable integer in the volume of proceedings.

MINUTES AND BALANCE SHEET.

Meeting of the Council held at the Museum, Leeds, April 13th, 1881.

Present, Mr. W. Sykes Ward in the chair, Prof. Miall, Messrs. Sladen, Reynolds, Atkinson, Holt, Rowley, Bedford, Gregson, and Hon. Secretary.

The Minutes of last meeting were read and confirmed.

The following Accounts were ordered to be paid :—

McCorquodale	£6	4*s*.	6*d*.
Leitch & Co.	3	0	3
Hy. Sykes	1	1	0
"Northern Echo"	0	9	0

Moved by Mr. Sladen, seconded by Mr. Gregson and carried—"That the next meeting of the Society be held at Hull, on Wednesday, April 27th, 1881, at the Royal Institution, that Dr. Rollit be requested to preside, and that papers be read by Messrs. Cameron, Lamplugh and Clark,

The Hon. Secretary stated that he had received a letter from Mr. Crowther, tendering his resignation of the office of Assistant Secretary; and requesting that it be accepted, proposed that the thanks of the Council be given to Mr. Crowther for his uniform courteousness and attention during the years that he has held the office.—Carried.

The Hon. Secretary stated that the position and management of the Society having during the past few years considerably changed in character, and the appointment of Local Secretaries in all the centres of membership, having greatly reduced the labour formerly performed by the Assistant Secretary and the consequent necessity of a paid Secretary, he was of opinion that it was unnecessary to engage the services of another Assistant Secretary, and that with the occasional assistance of a clerk, the Honorary Secretary would be able to undertake all the duties pertaining to the secretarial office.

The subject was discussed at some length, and eventually on the ground that it is necessary to have a paid secretary to retain the connection existing between this Society and the Leeds Philosophical Society, it was resolved on the motion of Mr. Reynolds, seconded by Prof. Miall—"That it is desirable to continue the appointment of an Assistant Secretary resident in Leeds.—Carried.

General Meeting of the Society in the Lecture Theatre of the Royal Institution, Hull, on Wednesday, April 23rd, 1881.

A. K. Rollit, Esq., L.L.D., D.C.L., F.R.A.S., &c., occupied the chair and delivered an address.

The Minutes of the last general meeting were read and confirmed.

The following papers were read :—

1. A. G. Cameron, Esq., of H.M. Geol. Survey, "On the Subsidences above the Permian Limestone between Hartlepool and Ripon."
2. G. W. Lamplugh, Esq., "On the peculiar intermingling of Gravel and Boulder Clay in some Sections near Bridlington."
3. J. E. Clark, Esq., B.A., &c., "On a Deep Glacial Section at the Friend's Retreat at York."

Dr. Rollit, Messrs. Gleadhow, Banks Lee, Wilson and Whiteley were elected Members of the Society.

On the motion of Dr. Bowman, seconded by Mr. Cash, the thanks of the Society were given to Dr. Rollit for presiding, to the readers of papers, and to the Literary and Philosophical Society for the use of their rooms.

The members and friends partook of luncheon at the Imperial Hotel.

The party afterwards joined the members of the Hull Student's Association, and the Geological Section of the Literary and Philosophical Society, and proceeded by a special train to Withernsea.

Professor James Geikie, F.R.S., explained the geological features of the district with a general exposition of geological phenomena.

A vote of thanks was accorded to Prof. Geikie on the motion of Mr. Davis.

Meeting of the Council at the Museum, Leeds, July 27th, 1881.

Present—Prof. Green in the chair, Prof. Miall, Messrs. Brigg, Bedford, Atkinson, Reynolds and Davis.

Proposed by Mr. Atkinson, seconded by Mr. Reynolds, and carried—"That the Annual Meeting of the Members shall be held at Bradford, in October next."

Proposed by Mr. Bedford, seconded by Mr. Reynolds, and carried—"That the following Accounts be paid :—

E. Wormald	...	...	£25	19*s.*	9*d.*
A. Megson	...	...	33	5	4
Petty Cash	...	...	10	0	0

Proposed by Prof. Miall, seconded by Mr. Brigg, and carried—"That the post of Assistant Secretary be offered to Mr. Denny, at the salary of £10 per annum ; and that in the event of his declining, the same offer be made to Mr. E. Wilson ; and that a copy of the duties as submitted by the Honorary Secretary be sent in each case."

Annual General Meeting held in the Library of the Grammar School at Bradford, on Wednesday, October 12th, 1881.

Arthur Brigg, Esq., in the chair.

The Minutes of the last general meeting were read and confirmed.

The Honorary Secretary read an annual report, and a balance sheet prepared by the Treasurer.

The Chairman addressed the meeting and proposed—"That the report and financial statement, as read, be accepted and adopted," Dr. Alexander seconded the proposition, which was carried.

Proposed by Mr. J. R. Eddy, and seconded by J. W. Davis, and carried—"That the Marquis of Ripon be re-elected President."

Proposed by Mr. McLandesborough, seconded by Mr. Spencer and carried—"That the Vice-Presidents be re-elected."

Proposed by Mr. Tate, seconded by Mr. Steel, and carried—"That John Brigg, Esq., J.P., be re-elected Treasurer."

Proposed by Mr. Bedford, seconded by Dr. Alexander, and carried—"That James W. Davis, Esq., F.S.A., &c., be re-elected Honorary Secretary."

Proposed by Mr. Müller, seconded by Mr. Tate, and carried—"That the following gentlemen form the Council of the Society:—Wm. Alexander, M.D., J.P., ; R. Carter, C.E., F.G.S. &c.; J. Ray Eddy, Esq. ; T. W. Embleton, C.E. ; E. Filliter, C.E., F.G S. ; Prof. A. H. Green, M.A., &c.; H. P. Holt, C.E., F.G.S.; Prof. L. C. Miall, F.G.S.; R. Reynolds, F.C.S.; W. P. Sladen, F.L.S., F.G.S.; H. C. Sorby, L.L.D., F.R.S., &c.; W. Sykes Ward, F.C.S."

Proposed by Mr. Davis, seconded by Mr. Bedford, and carried—"That Ed. Wilson, Esq., M.A., &c., be elected Honorary Local Secretary at Hull."

Proposed by Mr. Davis, seconded by Mr. McLandesborough, and carried—"That the following gentlemen be elected members of the Society :—Thos. Ormerod, Esq., Brighouse ; C. P. Anderson, Esq., Cleckheaton ; Wm. Horne, Esq., Leyburn ; W. Colbeck Dyson, Esq., Wilton Park,

Batley; Fredk. Crowther, Esq., Northowram, Halifax; Arthur Brigg, Esq., Rawden, Bradford.

Proposed by Mr. Bedford, seconded by Mr. Tate, and carried—"That George Ward, Esq., F.C.S. be elected a member of the Society."

The following papers were read:—

1. E. B. Poulton, Esq., M.A., &c., "Preliminary report on the investigation of the Dowkerbottom Cave."
2. Thos. Fairley, Esq., F.R.S.E., "On the Blowing Wells near Northallerton."
3. James Spencer, Esq., "On Astromyelon and its affinities."
4. G. R. Vine, Esq., "On the Polyzoa of the upper Limestone Shale of Hurst and Richmond."
5. John Holmes, Esq., "On certain discoveries of Bronze Implements near Leeds."
6. Joseph Lucas, F.G.S., "On Vestiges of the Ancient Forests of part of the Penine Chain."
7. J. R. Mortimer, F.G.S., "On the section of the drift obtained during the excavations for new drainage at Driffield."
8. J. R. Dakyns, Esq., M.A., "On Flots."
9. J. E. Marr, Esq., B.A., F.G.S., "On some sections in the Lower Palæozoic Rocks in Craven."
10. E. Wilson, Esq., F.G.S., "On a discovery of Fossil Fishes in the New Red Sandstone of Nottingham."
11. Thos. Hick, Esq., B.A., B.Sc., and Wm. Cash, Esq., F.G.S., "On a Contribution to the Fossil Flora of the Lower Coal Measures of Halifax."

Mr. Tate proposed, and Mr. Davis seconded, and it was carried—"That the next meeting of the Society be held at Dewsbury."

Mr. Eddy proposed, and Mr. J. R. Tennant seconded, and it was carried—"That the thanks of the Meeting be given to the contributors of papers."

Proposed by Mr. Parke, seconded by Mr. Tate, and carried—"That thanks be given to the chairman for presiding."

The proceedings then terminated, and the members dined together at the Talbot Hotel.

Statement of Receipts and Expenditure of the West Riding Geological and Polytechnic Society,

FROM OCTOBER 1st, 1880, TO SEPTEMBER 30th, 1881.

DR.	£	s.	d.	CR.	£	s.	d.
To Balance ...	2	10	0	By Cash paid into the Bank	93	3	10
,, Subscriptions	102	1	0	,, Stationery	39	18	10
,, Beckett & Co.	95	10	8	,, Postage and Carriage	5	19	1
,, Reports, &c., Sold	1	18	6	,, Cost of Photographs	29	16	3
				,, Expenses	9	7	2
				,, Salary of Assistant Secretary (11 months)	13	15	0
				,, Balance in hand	10	0	0
	£202	0	2		£202	0	2

The Treasurer in Account with Beckett & Co.

	£	s.	d.		£	s.	d.
To Balance at Bank	33	11	11	By Cash from Bank	95	10	7
,, Cash paid to Bank	93	3	10	,, Balance in Bank	32	4	7
,, Interest	0	19	5				
	£127	15	2		£127	15	2

The Treasurer in Account with Beckett & Co.

CAPITAL ACCOUNT.

	£	s.	d.		£	s.	d.
To Balance at Bank	88	5	3	By Balance in Bank	121	0	0
,, Cash paid to Bank	31	10	0				
,, Interest...	1	4	9				
	£121	0	0		£121	0	0

Examined and found correct, J. RAY EDDY.

Summary of Geological Literature relating to Yorkshire, published during 1881, with Addenda for 1880.

Compiled by James W. Davis.

1880—ADDENDA.

Barrow, G. On the Cleveland Ironstone. Part 2. *Proc. Cleveland Inst. Eng.* Sess., 1879-80, No, 6, pp. 180-187.

——— On the Cleveland Ironstone. Part 1. *Proc. Cleveland Inst, Eng.*

Davis, W. On the Bones of the Lynx, from Teesdale, obtained by Mr James Backhouse of York. *Geol. Mag.*, N.S., dec. ii., vol. vii., p. 346.

Ricketts, C. On the Carboniferous Limestone near Skipton and in North Derbyshire. *Proc. Liverpool Geol. Soc.*, vol iv., p. 132.

Watts, W. Geological Strata, and mode of proceeding in driving a tunnel, at Saddleworth. *Trans. Manch. Geol. Soc.*, vol. xv., p. 352.

1881.

Allison, T. Notes on the Geology of the Cleveland District. *Proc. York. Geol. and Poly. Socy.*, vol. vii, p. 285.

Bird, C. A Short Sketch of the Geology of Yorkshire. Pp. 196, 8vo, *Bradford.*

Dakyns, J. R. On Glacial Deposits north of Bridlington. *Proc. York. Geol. and Polyt. Socy.*, vol. vii., p. 246.

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METEOROLOGY OF BRADFORD FOR 1881.

Computed from daily observations made at the Exchange, Bradford, by J. McLandsborough, M. Inst. C.E., F.R.A.S., F.G.S.

Latitude, 53 deg. 47 min. 38 sec. N.; longitude, 1 deg. 45 min. 4 sec. W.; height above mean sea level, 366 feet.

Months	Pressure of Atmosphere in Month: Highest Reading of Barometer	Date	Lowest Reading of Barometer	Date	Range	Corrected for Capillarity, Temperature, &c.: Mean	Mean of 13 Years	Temperature of Air in Month: Highest	Date	Lowest	Date	Range	Mean: Of all Highest	Of all Lowest	Daily Range: Mean	Mean of 13 years	Of Dry Bulb	Adopted Mean Temperature: Of Air: Mean	Mean of 13 years	Of Evaporation	Dew Point
	Ins	On	Ins.	On	Ins	Ins.	Ins.	Deg.	On	Deg.	On	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg	Deg	Deg
January	30 346	7th	28 512	29th	1 834	29 484	29 509	46 5	3rd	12 0	26th	34 5	34·8	25 9	8 9	8 9	30·9	30 5	38 4	29·4	26 3
February	30 003	21st	28 422	10th	1 581	29 365	29·462	50·6	5th	26 6	24th	24·0	40 3	32 1	8·2	9·0	36 0	35 9	39 6	35 2	34 1
March	30 116	17th	28 648	7th	1 468	29 446	29 500	53 6	18th	21 4	2nd	32 2	45·2	34 8	10 4	11 4	39 5	39 3	40 6	38 2	36 8
April	29 870	28th	29 406	21st	0 464	29 568	29 485	62 2	14th	27 4	4th	34 8	50 0	37 4	12 6	13 6	42 6	42 4	45 4	39 6	36 2
May	30 382	10th	28 988	16th	1 394	29 669	29 569	77 0	30th	34 9	11th	42 1	62 3	45 2	17 1	14 6	52 4	52 2	49 3	46 9	41 5
June	29 950	1st	29 102	21st	0 848	29 548	29 538	80 8	1st	38 2	9th	42 6	64 7	49 6	15 1	15 2	55 4	55 4	55 8	50·4	45 7
July	29 918	14th	29 224	25th	0 694	29 533	29 527	83 3	6th	46 2	21st	37 1	68 5	54 3	14 2	15 0	60 2	59 8	60 7	55 0	50 8
August	29 992	4th	28 774	26th	1 218	29 350	29 501	79 6	6th	46 6	31st	33 0	63 3	51 6	11·7	14·4	55 6	55 6	59 1	52 2	49 0
September	30 004	29th	29 080	21st	0 924	29 573	29 500	67 1	21st	43 0	18th	24 1	60 3	48 8	11·5	12 8	54 2	53 7	54 7	50 8	48 0
October	30 150	7th	28 250	14th	1 900	29 599	29 445	63·4	1st	26 8	31st	36 6	50 9	40 3	10 6	10 9	45 2	44 9	48 1	42 5	39 7
November	29 972	13th	28 254	27th	1 718	29 415	29 442	58 4	14th	29 6	1st	28 8	52 4	42 6	9 8	9 2	47 5	47 3	42 2	44 8	42 1
December	30 160	27th	28 394	20th	1 766	29·490	29 470	52·3	3rd	26 0	10th	26 3	43 8	35 5	8 3	8 5	40 5	40 1	38 7	33 5	36 4
Means, or totals	30 072		28 755		1 317	29 503	29 495	64 6		31·6		33·0	53 0	41 5	11·5	12 0	46 7	46 4	47 7	43 6	40 5
Means of 13 years	30·059		28 892		1·167	29 495	29 495	64·9		33·4		31 5	54·7	42·6	12·1	12 0	48 0	47·7	47·7	44 6	41 2

Months	Vapour: Elastic Force	In a Cubic Foot of Air: Mean	Short of Saturation	Degree of Humidity (Complete Saturation = 100): Highest	Date	Lowest	Date	Mean	Mean of 13 years	Mean Weight of a Cubic Foot of Air	Highest Reading of Maximum Thermometer in Rays of Sun	Date	Mean Reading of Maximum Thermometer in Rays of Sun	Wind: Highest Estimated Strength	Date	Mean Estimated Strength	Direction: Relative Proportion of at 9 a.m.: N	NE	E	SE	S	SW	W	NW	Mean Amount of Cloud	Rain: Number of Days it fell	Amount Collected	Mean of Thirteen Years	Greatest Daily Fall	Date
	Ins.	Grs	Grs	0 100	On	0 100	On	0—100	0 100	Grs	Deg	On	Deg	0 6	On	0 6	No.	No	No	No.	No.	No.	No.	No.	0 10	No.	Ins	Ins	Ins	On
January	·142	1 7	0 3	95	28th	56	14th	86	86	558	53 6	31st	40 8	2 0	6th	0 7	1	9	1	5	2	5	3	5	7 0	10	0 23	2 34	0 04	28th
February	·196	2 3	0 2	97	7th	74	11th	93	86	549	59 5	28th	49 9	3 0	7th	0 7	0	9	2	8	1	1	3	4	8 1	20	4 03	2 02	0 98	14th
March	·219	2 5	0 3	96	7th	63	24th	91	83	547	75 6	18th	57·9	2 5	8th	1 0	0	7	0	7	1	6	5	5	6 6	19	4 08	2 19	1 23	5th
April	·211	2 5	0 3	95	15th	50	28th	79	77	546	89 0	18th	71 7	2 0	5th	1 1	0	8	6	7	1	1	5	2	6 1	15	1 48	1 94	0 42	15th
May	·262	3 0	1 5	87	5th	38	31st	68	74	537	111 0	29th	86 3	1 5	5th	0 7	0	4	3	6	0	6	11	1	4·2	15	1 48	1 97	0 25	26th
June	·308	3 5	1 6	87	25th	38	2nd	70	72	531	116 5	1st	86 5	1 5	9th	0 7	1	3	1	3	2	7	6	7	7 1	17	2 13	2 40	0 63	6th
July	·371	4 1	1 6	90	31st	39	5th	72	70	526	107 3	16th	88 8	1 5	3rd	0 8	0	2	0	2	3	14	7	3	6 1	17	3 27	2 68	0 94	5th
August	·349	3 9	1 1	97	25th	52	5th	79	74	527	103 2	6th	80 0	2 0	11th	0 8	1	4	1	6	1	3	8	7	7 0	23	3 75	2 99	0 93	25th
September	·334	3 8	0 9	96	23rd	51	29th	81	78	533	94 4	17th	75 8	2 0	21st	0 8	0	10	5	3	2	4	5	1	5 8	19	3 11	2 97	0 71	21st
October	·245	2 8	0 6	98	14th	60	17th	83	83	543	82 6	3rd	65 3	2 5	14th	1 1	0	9	4	7	1	2	5	3	6 7	22	4 26	3 54	1 43	13th
November	·268	3 1	0 6	96	16th	59	22nd	83	83	537	67 6	13th	57 0	3 0	27th	1 1	0	2	1	6	2	13	5	1	7 2	25	4 58	2·78	0 76	26th
December	·215	2 5	0 4	98	16th	74	2nd	37	84	547	56 5	30th	50 3	2 5	26th	1 0	1	2	0	5	4	9	6	4	7 8	21	3 03	2 81	0 65	16th
Means, or totals	260	3 0	0 8	94		55		81	79	540	84·7		67 5	2 2		0 9	4	69	24	65	20	71	69	43	6 6	223	35 43	2 55	0 76	
Means of 13 years	·267	3 0	0·9	94		60		79	79	539	91 6		70·6	3 0		1 1	29	55	29	37	25	63	77	50	6 6	182	30 62	30 62	0 69	

Yearly Maximum and Minimum Atmospheric Pressure, Temperature, Humidity, and Rainfall, from 1869 to 1881 inclusive.

EXPLANATION.

The observations are made at nine a.m, and, with the exception of **maximum and minimum thermometer** readings, again at three p m.

The highest and lowest barometric readings for each month, also the monthly range, are given as recorded; while the mean pressure is deduced from bi-daily observations corrected for index error, capillarity, temperature, and diurnal range To correct for altitude or reduce to sea level the air temperature being 48 degrees and barometer reading 30 inches at sea level), add ·401 inches to the heights given

The adopted mean temperature of air is deduced from the dry bulb and the maximum and minimum readings, the temperature of evaporation from the dry and wet bulb and the maximum and minimum readings. The dew point, elastic force of vapour, humidity, &c, are deduced from bi-daily readings of the dry and wet bulb hygrometer, by Glaisher's Hygrometrical Tables, sixth edition

The solar thermometer has a black bulb enclosed in a vacuum

Year.	Pressure: Highest: Reading of Barometer during Year.	Date.	Lowest: Reading of Barometer during Year.	Date.	Temperature: In Shade: Highest: Reading of Maximum Thermometer during Year.	Date	Lowest: Reading of Minimum Thermometer during Year.	Date	Last and First Frost of Seasons: Date of Last Frost.	Date of First Frost.	In Sun's Rays: Highest: Reading of Solar Thermometer during Year.	Date	Humidity (Complete Saturation = 100): Highest: Degree of Humidity during Year.	Date.	Lowest: Degree of Humidity during Year.	Date	Rain: Total for Year	Greatest Daily Fall during Year.	Date	Snow: Last and First Snow of Seasons: Date of Last Snow	Date of First Snow
	Ins.		Ins		Deg.		Deg.				Deg		0 100		0—100		Ins	Ins			
1869	30 290	Dec. 6	28 500	Feb. 1	85 2	Aug. 30	19·8	Dec. 28	Mar. 27	Oct. 20	127 7	Aug. 30	99	Feb. 8	42	Sep 24	24 480	0 870	Dec 18	April 3	Oct 19
1870	30 284	Jan. 19	28 308	Jan. 8	85·0	July 25	16 6	Dec. 23	Mar 30	Nov. 9	127 5	July 25	98	Jan 29	40	July 14	24 120	0 820	June 18	Mar. 24	Nov 15
1871	30 152	Mar 28	28 308	Jan. 16	84 0	Aug. 12	6 7	Jan 1	April 11	Nov 13	128 7	July 17	98	July 7	43	Nov. 2	21 640	0 985	June 16	Mar 15	Nov 16
1872	30 156	April 6	28 070	Jan. 24	86 4	July 23	24 8	Mar 27	Mar. 27	Nov. 19	124 8	Aug. 19	100	Mar. 22	45	Sep. 23	42 060	2 490	June 19	May 11	Nov. 13
1873	30 338	Feb. 18	28 022	Jan 20	88 8	July 23	19 2	Feb 24	Mar. 14	Nov 5	124 5	July 23	100	Dec. 11	41	Mar 26	21 440	1 200	Aug 4	April 25	Jan 3, '74
1874	30 476	Mar. 6	28 276	Dec 11	80 9	July 20	15 0	Dec. 31	Mar 12	Nov 11	125 8	July 20	100	Feb. 6	42	May 18	23 560	0 740	Dec 7	May 9	Nov. 26
1875	30 305	July 7	28 484	Nov 10	80 0	Aug. 17	13 0	Jan 1	Mar 22	Nov. 26	122 0	July 5	100	Jan. 23	43	July 6	30 280	1 700	Nov 15	Mar. 12	Nov 9
1876	30 300	Jan 15	28 070	Dec. 4	87 6	July 17	23 0	Jan 9	April 15	Nov. 9	125 6	July 16	99	Oct. 4	46	May 5	35·270	1 810	Oct. 9	April 12	Nov. 8
1877	30 358	Oct. 6	28 300	Nov. 29	80 0	June 19	20 0	Mar. 1	May 4	Oct 18	116 4	June 19	100	Oct 29	35	May 23	40 650	1 420	July 16	May 19	Oct 15
1878	30·320	Mar 16	28 630	April 1	89 6	July 19	13 9	Dec. 26	April 6	Nov. 9	118·2	July 22	99	Jan. 13	53	Aug. 9	35 434	1 220	Aug 14	April 1	Nov. 8
1879	30 352	Dec. 13	28·500	Feb 10	74 4	July 30	13 2	Dec. 7	May 10	Nov. 14	101 2	Aug 13	100	Oct. 7	51	Dec 12	28 017	1·020	June 8	May 7	Nov. 20
1880	30 332	Jan. 7	28·164	Nov. 16	81·3	Sep. 5	20 8	Jan. 20	Feb. 23	Oct 20	112 0	Aug 13	99	Dec. 15	50	May 30	35 690	1 710	Oct. 27	Mar 2	Oct 27
1881	**30·382**	**May 10**	**28·250**	**Oct. 14**	**83·3**	**July 6**	**12 0**	**Jan. 26**	**April 21**	**Oct. 17**	**116·5**	**June 1**	**98**	**Oct. 14**	**38**	**May 31**	**35·434**	**1·435**	**Oct. 13**	**April 20**	**Oct. 29**
Means	30 311		28 298		83·6		16·8				120·8		99		44		30·621	1·340			

The force of wind is estimated by a scale ranging from 0 to 6, the square of the number of scale giving the pressure in pounds per square foot. The direction is given as shown by vane.

The amount of cloud is estimated by a scale ranging from 0 to 10.

The rain gauge is 65½ feet above the surface of ground, and therefore registers less than if on the surface. Gauges placed on the surface to at the Town Hall and at the Midland Railway Station show the mean yearly rainfall at these places for the six years ending with 1881 to be 39 017 inches, while that at the Exchange for the same period amounts to 35 086 inches, or 3 931 inches less than on the surface.

All the instruments with which the observations are made have been verified by comparison with the standards at Kew Observatory.

The mean of thirteen years, where given, is for that period ending with 1881.